INFLUENCE OF TIMURID ARCHITECTURE ON SAFAVID AND MUGHAL MOSQUES IN INDIA

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ABSTRACT

Before and after the advent of Islam, Persian architecture was heavily influential towards the structures of the Indian subcontinent. During the Mughal era (1526-1707AD), bilateral relations between Persia and India reached the highest level in all aspects of life. Even though the Mughal period was contemporaneous of the Safavid (1524-1736), many historical evidences hold that Mughal architecture was mostly influenced by the Timurid dynasty (1370-1526) more than Safavid architecture, with Timurid architecture serving as a prototype for both Safavid and Mughal styles. The main objective of this study is to investigate the influence of Timurid architectural elements (1370-1525) in Mughal mosques of India (1526- 1707AD). Mughal mosques were selected in this research due to the fact that despite the importance of mosques in the Islamic world.

The main question is how Timurid architectural elements were transferred to and influenced Mughal buildings (1526-1707AD) in the Indian subcontinent. Hence, this research explored the Timurid architectural influence in Mughal mosques by examining the selected historical buildings using qualitative multiple case studies and by collecting multiple sources of data for each case study. The validation of research as a qualitative study involves triangulation, which means triangulating different sources and using it to build a coherent justification for the themes.

Moreover, this research focused on the transfer of Timurid architectural elements that were innovated and inserted to the mosques of Persia by Persian master builders. These elements may be innovated in Timurid period or may have been developed and used from the pre-Timurid era. The five most important factors are *ivan*, domed chamber, double

dome, *squinch*, and pointed arch. Each of these elements was closely examined during the course of the case study.

By locating the historical evidences, the routs and channels of architectural influence could be defined and verified, and then the results of each case study analysed based on five architectural elements were compared in three phases to demonstrate the Timurid architectural influence in early and high Mughal periods separately. Finally, the evolution and alteration of Timurid influence during the Mughal period (early and high phases) were studied.

The finding of the research highlighted that formal elements (both structural and ornamental), including pointed arch, *squinch*, and double domes could be used near the original faces with minimal changes in both early and high Mughal phases. While the domed chamber and *ivan* as functional elements were needed to match Mughal mosques due to the differences between Timurid and Mughal mosques in term of design and concept. Moreover, both functional elements in the early phase of the Mughal era have more levels of similarity with Timurid architecture compared to the high phase. Between the proportions of *Ivans* and domed chamber, the *Ivans* of Mughal mosque were more match to Timurid architecture .The vertical proportions of both functional elements in Mughal mosques were more match than the horizontal proportion to Timurid architecture.

ABSTRAK

Sebelum dan selepas kedatangan Islam, seni bina Parsi adalah sangat mempengamhi ke arah struktur benua India. Semasa era Mughal (1526 - 1707AD), hubungan dua hala antara Parsi dan India mencapai tahap tertinggi dalam semua aspek kehidupan. Walaupun tempoh Mughal sezaman dengan Safavid (1524-1736), bukti-bukti sejarah menunjukkan bahawa seni bina Mughal kebanyakannya dipengaruhi oleh dinasti Timurid (1370-1526) lebih daripada seni bina Safavid, dimana seni bina Timurid berfungsi sebagai prototaip bagi gaya seni bina Safavid dan Mughal. Objektif utama kajian ini adalah untuk menyiasat pengaruh unsur-unsur seni bina Timurid (1370-1525) di masjid-masjid Mughal di India (1526 - 1707AD). Masjid-masjid Mughal telah dipilih untuk kajian ini kerana kepentinhan masjid- masjid ini dalam dunia islam .

Persoalan utama adalah bagaimana unsur-unsur seni bina Timurid dipindahkan dan mempengaruhi bangunan Mughal (1526 - 1707AD) di benua India. Oleh itu, kajian ini menerokai pengaruh seni bina Timurid di masjid-masjid Mughal melalui pemeriksaan ke atas bangunan bersejarah yang dipilih. Metodologi menggunakan "*qualitative multiple case studies*" iaitu pelbagai sumber data untuk setiap kajian kes. Pengesahan penyelidikan kajian kualitatif melibatkan triangulasi, dari sumber yang berbeza dan menggunakannya untuk membina sebuah justifikasi yang koheren bagi setiap tema.

Selain itu, kajian ini memberi tumpuan kepada pemindahan unsur-unsur seni bina Timurid yang diinovasikan dan dimasukkan ke masjid-masjid Parsi oleh pembina induk Parsi. Elemen-elemen ini kemungkinannya diinovasikan oleh Timurid atau sejak era zaman pra- Timurid. Lima faktor yang paling penting jalah *Ivan* , *domed chamber*, *double*

dome, squinch , dan *ponited arch*. Setiap unsur ini telah diperiksa dengan teliti semasa kajian kes.

Daripada pencarian bukti-bukti sejarah, perjalanan dan saluran pengaruh seni bina boleh ditakrifkan dan disahkan, dan seterusnya keputusan setiap kajian kes dianalisis berdasarkan lima elemen seni bina yang telah dibandingkan dalam tiga fasa untuk menunjukkan pengaruh seni bina Timurid dalam tempoh awal dan akhir Mughal secara berasingan. Akhir sekali, evolusi dan perubahan pengaruh Timurid dalam tempoh Mughal awal dan akhir telah dikaji.

Penemuan penyelidikan menekankan bahawa unsur-unsur formal (struktur dan hiasan), termasuk *double dome*, *squinch*, dan *pointed arch* boleh digunakan berdekatan ciri-ciri asli dengan perubahan minimum dalam kedua-dua fasa awal dan akhir Mughal. Manakala *domed chamber* dan *ivan* sebagai unsur fungsian diperlukan untuk menyerupai masjid Mughal disebabkan perbezaan antara masjid-masjidTimurid dan Mughal dari segi senireka dan konsep. Selain itu, kedua-dua elemen fungsian di dalam fasa awal era Mughal mempunyai lebih persamaan dengan seni bina Timurid berbanding dengan fasa akhir. Antara nisbah *ivans* dan *domed chambers*, masjid-masjid Mughal berunsur *ivans* adalah lebih menyerupai seni bina Timurid. Bahagian menegak kedua-dua unsur fungsian dalam masjid-masjid Mughal lebih menyerupai seni miba Timuirid daripada bahagian mendatar.

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LIST OF GLOSSARY

Chahar taq	**:**	Four arch
Chahar bagh	:	A type of Persian garden
Chamaneh	:	A type of islamic persian pointed arch
Haft rangi	:	Seven-colour painted tile
Hammam	:	Public bath
Ivan	:	Portico
Jami	:	The biggest mosque of the city
Kalil	:	A type of islamic persian pointed arch
Madrasa	:	Religious school
Masjid	:	mosque
Mihrab	:	Is a niche in the wall of a mosque that indicate qibla, and which Imam stands of prayers
Moqarnas	:	Is a three dimensional decoration of Islamic architecure
Parthian	:	Pre-Islamic Persian empire (247BC-224AD)
Pishtaq	:	projecting portal
Qibla	:	Is an arabic word for the direction that should be faced when a Muslims pray during salah
Sasssanian	:	Last pre-Islamic Persian empire (224-651CE)
Seh-Bakhshi	:	A type of islamic persian pointed arch

Shabdari : A type of islamic persian pointed arch

Shakhbozi : A type of islamic persian pointed arch

Squinch : Is a piece of construction used for fillng in the upper angels of a squrae room as to form propper base to receive an octagonal or spherical dome.

Pang-O-Haft : A type of islamic persian pointed arch

Patopa : A type of islamic persian pointed arch

Rasmi sazi : Intesecting arch

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CHAPTER 1: INTRODUCTION

In the form of historical research, this thesis studies the influence and effect of one style (Timurid architecture) to another (Mughal architecture). A number of building constructed during the Timurid period (1370-1525AD) was selected and compared to the influence of the Mughal period (1526-1707AD), which constitute one of important aspects and aesthetic aim, as mentioned by David Watkin (1983, pp. 1-6), where the aim of architectural history can be divided into three parts; practical, historical, and aesthetic aim.

The aesthetic aim of the subject is to analyze and suggest the meaning of the buildings and the reasons for their stylistic change throughout history. This will be the main thrust of the research investigation.

This thesis focuses on the aesthetic aim, where two other aims (practical and historical) are addressed in the literature review of the thesis. The practical aim of the subject is the identification of the buildings in terms of its date of construction and completion. The second part of architectural history aims to ascertain the reason the buildings were constructed. The historian will have to rely on the interpretation of the religious, sociological, and cultural source in order to perform this task.

The framework of this study encompasses three different aspects that are important in understanding the history of architecture of a selected group of buildings. In comparing the Timurid architecture of the period with the Mughal architectural samples, a detailed investigation resulted in how the influence of the artisans, builders, political decisions, cultural and economic relations were important. How the architectural elements from the Timurid period entered, influenced, and modified Mughal mosques, whereas only the size of the Mughal mosques differs, and the general forms of Mughal mosques was altered.

1.1. Background of Research

Many architectural historians believe that the history of international relations indicated that from the many elements strengthening reciprocal relation among nations, socio-cultural relation has always been more effective and sustainable compared to economic and political ones. The former has roots in the beliefs, traditions and values of the respective societies, while the latter may be altered by a change in governance. Moreover, socio-cultural relation has not fixed the boundaries of countries and nations in the history of humanity. Migration and trade of artists, artisan, scholars and traders precipitated direct and indirect influence between countries and nations. Art, as one of the strongest elements of cultural relations, can play a very effective role in linking nations (Kaminsky, 1962; Pourjafar & Taghvaee, 2004; Stierlin & Stierlin, 2002).

One of the best countries that had great and continuous multi-relations with its neighborhoods and other countries and civilizations was Persia. Persia today is virtually off the great highways of the world, but in the ancient world, she was the connecting link between the East and the West. The legacy of Persia to the world from the grey dawn of civilization to the medieval ages, as a land bridge between East and West, was due to her position astride the great routes of Asia. Many historical evidences indicated great extent of cultural, architectural exchange and relation between Persia and other countries and nations (Nazimuddin, 1974; Pereira, 1994; Pope, 1965; Stierlin & Stierlin, 2002)

Western scholars described Iran, its people and empires via the prism of Persia. This area was the core of the original Persian Empire at various times of history. The territories concerning all belonged at one time or another to a Persian kingdom or empire. Before the modern era, the empire of Persia expands beyond the modern frontier of Iran in all directions. The state was referred to as Persia until March 21, 1935, when Reza Shah Pahlavi formally asked the international community to refer to the country as Iran (Stierlin & Stierlin, 2002; Zandian.N., 2007).

The architecture of Persia is quite distinct from its Arab, Armenian, Ottoman, and Hindu neighbors. From pre-Islamic times onward, Iran has been a land of great empires – the Achamenids (550-330 BCE), the Seleucids (312-63BCE), the Parthians (247 BCE - 224AD) and the Sasanian (224-651AD). Islam was introduced into Persia in the second half of 7th century, and strengthened its hold in the 8th and 9th centuries, where Persia formally adopted Islam as a state religion. Throughout succeeding centuries, the presence of powerful foreign rules – Seljuk Turk, Mongols (Illkhanid) and Timurid – did not affect Persia's distinctive character, since these nomadic and semi-nomadic newcomers were rapidly assimilated. They took over and assimilated the essence of art and architecture, and also the spirit of Persians (pirnia, 2001; Stierlin & Stierlin, 2002).

Table 1.1 represents that based on the view of several art historians, the main and important Persian Islamic periods include the Early period (623-1071AD), Seljuk(1071-1194AD), Illkhanid(1256-1335AD), Timurid(1370-1526AD), Safavid(1502- 1736AD).

Table1.1: Classification of Persian Islamic historical periods based on experts (Author-2011)

No	Name of expert	Classification of Islamic historical periods based on experts
1	(Pope, 1965)	Early period, Seljuk , Illkhanid, Timurid, Safavid
2	(Hillenbrand, 1994)	Early period, Seljuk , Illkhanid, Timurid, Safavid
3	(Pereira, 1994)	Middle Iranian Islamic periods: Sassnio Islamic , Seljuk, Illkhanid , Timurid Late Iranian Islamic period : safavid (west) & Shaybanid (east)
4	(pirnia, 2001)	Early period, Seljuk , Illkhanid, Timurid, Safavid
5	(Habib, 2002)	Illkhanid, Timurid, Safavid
6	(Stierlin & Stierlin, 2002)	Early period, Seljuk , Illkhanid, Timurid, Safavid
7	(Frishman & Khan, 2007)	Early period, Seljuk , Illkhanid, Timurid, Safavid

One of the best examples of Persian architectural influence is India. Before and after the advent of Islam, Persian architecture was heavily influential towards the structures of the Indian subcontinent, and the Persian style of architecture formed the basis of Indian architecture (Habib, 2002).

The most universal of the Indo-Muslim styles is the Mughal mode of the Muslim architecture, which prevails in the subcontinent, forming a pan-Indian style. In the 16th century, Persia witnessed the rise of the Safavid Empire, while India was contending with the corresponding rise of the Mughal dynasty. Both India and Persia were formidable powers under these respective dynasties (Islam, 1970). In the Mughal era, bilateral relations between Persia and India peaked in all aspects of life, so much so that it is called the “Golden Era” of the development of socio-cultural and political ties and close relations between the two countries (Pourjafar & Taghvaee, 2004). The Mughal patronage of culture constantly attracted Persian scholars; which resulted in talented Persians being absorbed into the ever-expanding services of the Mughal Empire (Islam, 1970).

Even though the Mughal period (1526-1707AD) was a contemporary of Safavid (1524_ 1736) , several scholars (Asher, 1991; Dale, 2004; Golombek, 1981; Habib, 2002; Hoag, 1968; Koch, 1991b; Pereira, 1994; Stierlin & Stierlin, 2002) indicated that Mughal architecture was affected mostly by the Timurid dynasty (1370-1526) more than Safavid architecture, and even Timurid architecture was a prototype for both of Safavid and Mughal styles. For example, Koch(1991b), (in his book - *Mughal Architecture: An Outline of Its History and Development, 1526-1858)* mentioned that, since the Mughals were direct heirs of the Timurid. The sustaining elements of their architecture, especially during the initial phase, was Timurid, and as such, is the perfect symmetry of the plan reflected consistently in the elevations, as well as complex vaults patterns.

1.2. Research Gap

Based on the idea of several scholars, mentioned in the background of study, many different types of Mughal public buildings (1526-1707AD) were influenced by Timurid architecture (1370-1525AD). The best example of this influence can be seen in funerary buildings, mausoleums, gardens, and palaces. In Table 1.2, most architectural historian researchers and scholars focused on the influence of Timurid architecture in Mughal tombs, gardens, and then palaces.

Table 1.2: Reference classification of Timurid influence in Mughal architecture based on function type (Author-2011)

No	function	Reference
11	Tomb & mausoleum	(Asher, 1991; Golombek, 1981; Habib, 2002; Hillenbrand, 1992; Hoag, 1968; Koch, 1991a; Nath, Hasan, Beg, & Heritage, 1985; Parodi, 2000; Pourjafar & Taghvaee, 2004; Soltanzadeh, 1999; Stierlin & Stierlin, 2002)
22	Garden	(Ansari, 1999; Dale, 2004; Golombek, 1995; Habib, 2002; Jatinder Pal, 2011; lrving, 1984; Moynihan, 1979; Pourjafar & Taghvaee, 2004; Soltanzadeh, 1999; Stierlin & Stierlin, 2002; Stiny & Mitchell, 1980)
33	Palace	(Habib, 2002; Koch, 1991b, 1994; Stierlin & Stierlin, 2002)
44	Mosque	(Habib, 2002; Havell, 1913; Koch, 1991b)
55	*Madrassa*	(Koch, 1991b)
66	*Hammam*	(Habib, 2002)

One of greatest tombs that were highly influenced from Timurid architecture is the Taj Mahal and Humayun tombs, which is generally regarded as a prototype of the famed Taj Mahal of Agra. Taj Mahal should so often be regarded as the quintessence of the Mughal spirit, both in the quality of its combination of monumentality and delicacy, and in the quality of its decoration, it represents the culmination on Indian soil of the Timurid genius at work (Hambly, 1977; Smith, 1962), while other Timurid effects are seen in Mughal gardens. Designing Timurid gardens (is called *Chahar Bagh*) according to the importance of geometry and application of rectangular plan and its division in four parts in the shape of a cross or perpendicular streets has been used in Mughal gardens and yards of tombs and palaces (Ansari, Taghvaee, & Nejad, 2008; Smith, 1962).

Among the functions (mosques, *madrassa*, *hammam*) that were studies less than tombs, gardens in the issue of Timurid architectural influence, mosques had great situation in the Islamic world as essential function in all small and big cities. Beside that the number of *madrassa* and *hammam* are less than mosques in both Persia and India, hence the mosques of the Mughal dynasty have been selected for studying in this thesis (refer Table).

Comprehensive study of Timurid influence in Mughal mosques can be listed in the following order; Timurid aesthetical principles, Timurid architectural concepts, Timurid architectural elements, Timurid ornamentations, Timurid mosque typology, Timurid mosque morphology. Instead of a complete study about Timurid influence in Mughal mosque, some scholars (Koch (1991b) ,Habib (2002), Pereira (1994)) only focused briefly at certain levels, such as Timurid mosque typology and morphology.

For instance, Koch in (1991b) and Pereira (1994) studied the comparison of mosque typology between Timurid and Mughal mosques. They pointed out that Mughal mosques closely followed the Timurid prototype in certain aspects, including the application two *ivans* mosque and four *ivans* mosque, where the latter was the perfect and famous Timurid mosque type in Persia and other Islamic countries.

Some reference cited Timurid influence in the Mughal mosque morphology. The sequence and relation between *mihrab*, central chamber, and nave of the early Mughal mosques (mosques that were built in Babur and Humayun kings) were highly influenced by Timurid architecture (Habib, 2002; Koch, 1991b).

It can be concluded that a comprehensive and broad research regarding the transfer of Timurid architecture and influence over Mughal mosques at multiple level is currently unavailable.

1.3. Significance of Research

Despite the fact, that there have been studies describing the influence of Timurid architecture in Mughal buildings (such as tombs, funerary buildings, and gardens). There are only a few studies for issue of transfer of Timurid architecture to Mughal mosques. The significance of studying the influence of Timurid architecture in the Mughal mosques can be conducted from four distinct aspects.

First, the research reveals and concentrates on the existence of multi-relations between Persia and India, particularly in the Mughal period (1526-1707AD), where the relations peaked.

Second, the thesis is significant in that it shows the capacity, authority, and flexibility of Timurid architectural elements (1370-1525AD) to transfer, influence, and merge with the foreign styles the outside of Timurid territory. Indeed, these architectural elements alter the timeless and borderless elements that belong not only to the Timurid period, but also to Mughal.

Third, the significant of this historical study is to display the complete process of transition, from one architectural style (Timurid) to another (Mughal), both belonging to two different territories at different times. This process includes the transfer, influence, blending, and modification with foreign architecture.

Finally, due to the explanatory power of this historical research with regards to the stylistic transitions through time (from one style to another), it benefits architectural historians and architects, especially in the context of Middle East and Asian architecture as good samples from two important Asian regions (Persia and India).

1.4. Research Scope and Limitation

Among different levels of Timurid influence in Mughal mosques mentioned in the research gap, the influence of Timurid architectural elements was selected for this research. These elements may be innovated in the Timurid period, or developed and used from pre-Timurid period. Indeed, these elements were innovated and inserted to the mosques of Persia by Persian master builders. These architectural elements consist of pointed arch, *Ivan*, domed chamber, double-dome, *squinch*, intersecting arches (type of vault), arch and panel system, seven-colour tile (material), and mosaic faience (material).

This research is not without its limitations. As it will be described in the next chapter, all case studies are from Timurid, Safavid, and Mughal periods, located throughout several countries. Territories of Timurid mosques include Iran, Afghanistan, Turkmenistan, and Uzbekistan. The Safavid mosques are almost all located in Iran, while Mughal mosques are spread out in India and Pakistan. Due to the shortage of time and difficulty in visiting all samples, the case studies were selected from Iran and India as representative of Timurid, Safavid, and Mughal periods.

The second limitation is a common problem in historical research, where historical monuments are damaged or destroyed. Buildings that are not intact cannot be chosen for the purpose of this study.

1.5. Research Questions

RQ 1: **How were the Timurid architectural elements transferred to and influenced Mughal building (1526-1707AD) in the Indian subcontinent?**

RQ 1-1: Which routes were traced via Persia or India from Timurid architecture to Mughal buildings?

RQ 1-2: Which routes were traced directly or indirectly from Timurid architecture to Mughal buildings?

RQ 2: **What are the architectural elements that were originally Persian in the mosques of Timurid period (1370-1525AD) in Iran?**

RQ 3: **What are Timurid architectural elements that were transferred and influenced Mughal mosques of India (1526-1707AD), with emphasis on Persian geometrical analysis for specific spatial elements?**

RQ 3-1: Which Timurid architectural elements influence Mughal mosques directly via Timurid architecture?

RQ 3-2: Which Timurid architectural elements have influenced Mughal mosques indirectly via Timurid, and then Safavid, architecture?

RQ 4: **How and why Timurid architectural elements influence Mughal mosques in India; modified, evolved, and developed based on the two periodical Mughal phases (early and high)?**

RQ 4-1: Which Timurid architectural elements were changed and blended with Mughal architecture?

RQ 4-2: Which Timurid architectural elements were applied in the original face of Timurid architecture?

1.6. Research Aim and Objective

Introductory study shows that the Timurid period had a great and influential role in Mughal architecture (refer to background of study). In this research, firstly, the route and channel of Timurid architectural transfer to Mughal India have be studied (due to these two periods are non-concurrent), while in the second part, the influence and evolution of Timurid architectural elements in Mughal mosques can be assessed.

The main aim of this thesis is **to investigate the influence of Timurid architectural elements (1370-1525) in Mughal mosques of India (1526- 1707AD).**

The objectives in the pursuit of these aims are listed below:

Objective 1: **To define and verify the routes of Timurid architectural influence in Mughal buildings of the Indian subcontinent with regards to that of Timurid (1370-1525AD) and Mughal (1526-1707AD) periods were non-concurrent.**

Objective 2: **To identify the architectural elements that were originally Persian in the mosques from the Timurid period (1370-1525AD) in Iran.**

Objective 3: **To examine the selected Mughal mosques of India (1526-1707AD) that have been influenced by Timurid architectural elements, with emphasis on Persian geometrical analysis for specific spatial elements.**

Objective 4: **To define the evolution and alteration of Timurid architectural elements that influenced Mughal mosques in India based on two periodical Mughal phases (early and high) and other contributing factors.**

1.7. Research Design

A research design is a plan, structure, and strategy of investigation conceived in a way to obtain the answer to a research question or problem. The plan is the complete scheme or program of the research. It includes an outline of what the investigator will do, from writing the hypotheses and their operational implications, to the final analysis of data (Kumar, 2010).

Figure 1.1 illustrates research framework that was proposed for the organization of the thesis, and Table 1.3 summarizes the matrix of the research.

The first step is to study the secondary sources, including summaries of Persian and Indian architecture and the relations of these two empires, together with the routes of Timurid architectural transition to Mughal buildings. The literature review chapter is the answer to the first objective. The next step would be to select the case studies as a research approach from specific periods (Timurid, Mughal, and Safavid as moderators between Timurid and Mughal). The third step includes both secondary and primary data sources, firstly the architectural elements that were originally Persian and developed in the mosques of Persia will be studied from secondary sources, and then these architectural elements will be identified in Timurid case studies (objective two). The next step continues with the comparison of Timurid and Mughal case studies based on the results of previous step. This addresses the third objective. The final step is the evolution and alteration of Timurid architectural elements that influenced Mughal mosques (objective four).

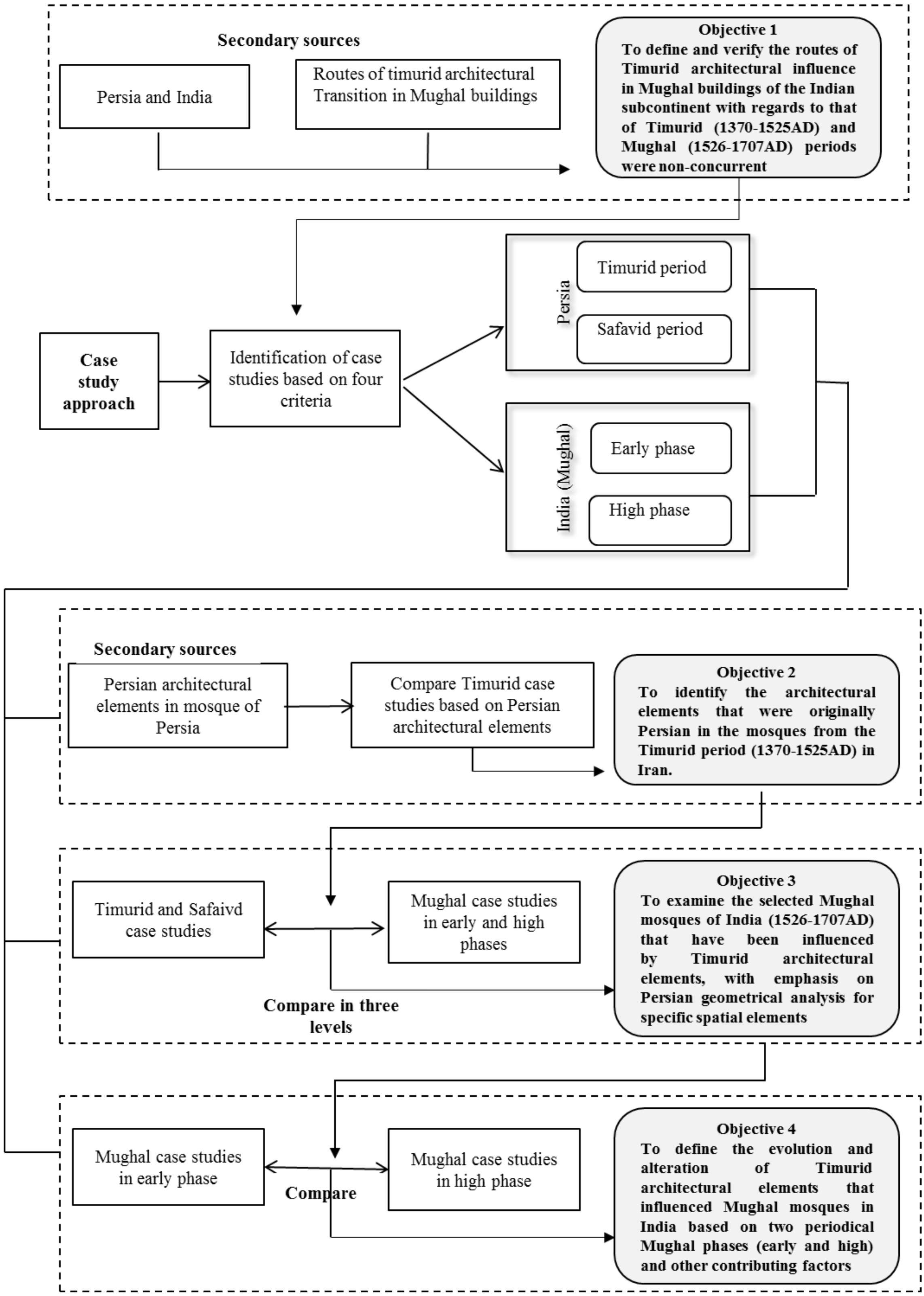


Figure 1.1: Framework of research design (Author-2011)

Table 1.3: Matrix of Research Framework (Author-2011)

Aim	Objective	Research Questions	Research Methods
To investigate the influence of Timurid architectural elements (1370-1525) in Mughal mosques of India (1526- 1707AD).	To define and verify the routes of Timurid architectural influence in Mughal buildings of Indian subcontinent with regarding that Timurid (1370-1525AD) and Mughal (1526-1707AD) periods were not concurrent.	How Timurid architectural elements transferred and influenced in Mughal buildings (1526-1707AD) in Indian subcontinent?	Secondary data (literature review)
	To identify the architectural elements which were originally Persian, in the mosque of Timurid period (1370-1525AD) in Iran.	What are the architectural elements that were originally Persian, in the mosques of Timurid period (1370-1525AD) in Iran?	Qualitative data (case study)
	To examine selected Mughal mosques of India (1526-1707AD) that have been influenced by Timurid architectural elements, with emphasize on Persian geometrical analysis for specific spatial elements	What are Timurid architectural elements that transferred and influenced in Mughal mosques of India (1526-1707AD) with emphasize on Persian geometrical analysis for specific spatial elements	Qualitative data (case study)
	To define the evolution and alteration of Timurid architectural elements that influence Mughal mosques of India based on two periodical Mughal phases (early and high) and contributing factors	How and why Timurid architectural elements that influenced in Mughal mosques of India, modified, evolved, and developed base on two periodical Mughal phases (early and high)?	Qualitative data (case study)

1.8. Research Methodology

The current study involves the investigation of the characteristics of one architectural period (Timurid) being transferred and influencing another (Mughal), while the focus of the research is the interpretation of historical events. Therefore, the identification and collection of evidence concerning historical events is required. In this case, the interpretative paradigm is best suited for this task. The multiple case study has been chosen as an approach for this research for a few reasons. The data for all case studies was gathered in the form of documentation, direct observation, and audio-visual materials. The most useful documentation is measured drawings for each case study (from governmental or personal documents) and administrative documents (unpublished case study information).

The explanation buildings technique, as one of the five analytical method, will be utilized to analyze the data (Yin, 2009b). The Persian architectural elements (*Ivan*, domed chamber, double dome, *squinch*, and pointed arch) will be studied in all case studies within three categories: typological, morphological, and geometrical studies.

In the results chapter and in the three levels, the analogous case studies will be compared. The first phase specifies the results of comparison between the Timurid case studies. The next phase explains the results of the comparison between Timurid and Mughal case studies directly and indirectly via Safavid architecture. This phase is made up of three levels. The third phase describes the comparative results of Mughal case studies.

1.9. Structure of Research

This thesis includes eight chapters, as illustrated in Figure 1.2. Chapter one explains the background of the study and an overview of the subject area of the research. The gap of research, scope, limitations, aim and objectives, research questions, and outlines of the structure of the research were also described.

Chapter two presents an overview of Persia and India, firstly, it summarizes Persian architectural periods after Islam, with focus on Timurid and Safavid eras. This is repeated in the case of India, summarizing Islamic Indian architectural periods by focusing on the Mughal period. This continues with an overview of architectural relations between Persia and India after the advent of Islam.

Chapter three defines the route of Timurid architectural transition in Mughal buildings. These routes are comprised of three propositions. The first one is direct Timurid influence on Mughal architecture, while second and third ones are indirect Timurid architectural influence during Indian and Persian periods. Moreover, the description of the historical evidences related to each propositions and the validity of each routes are also studied.

Chapter four addresses the Persian architectural elements in the mosques of Persia. It starts with a summary of history of Persian mosques and typology of Persian mosques, followed by the description of ten Persian architectural elements and information for each element comprising of the definition, summary of history, and morphological and typological review of element.

Chapter five reports the research methodology being adopted. It includes the research paradigm, research approach, data collection method, and analytical techniques. Furthermore, it explains the rationales for each of the procedural steps.

Chapter six presents the details of the seven case studies (three Timurid, one Safavid, and three Mughal). The information for each case study includes the summary of history and architecture, and typological, morphological and geometrical analysis of five Persian architectural elements (*Ivan*, domed chamber, double dome, *squinch*, and pointed arch).

Chapter seven presents the analysis and findings in the third phase; the first phase compares Timurid case studies. The next phase compares Timurid and Mughal case studies in three levels (with regard direct and indirect Timurid influence), and the third phase describes the comparative results of Mughal case studies.

Chapter eight, which is the final chapter of the thesis, summarizes the major findings. It concludes the research and recommended future actions and research.

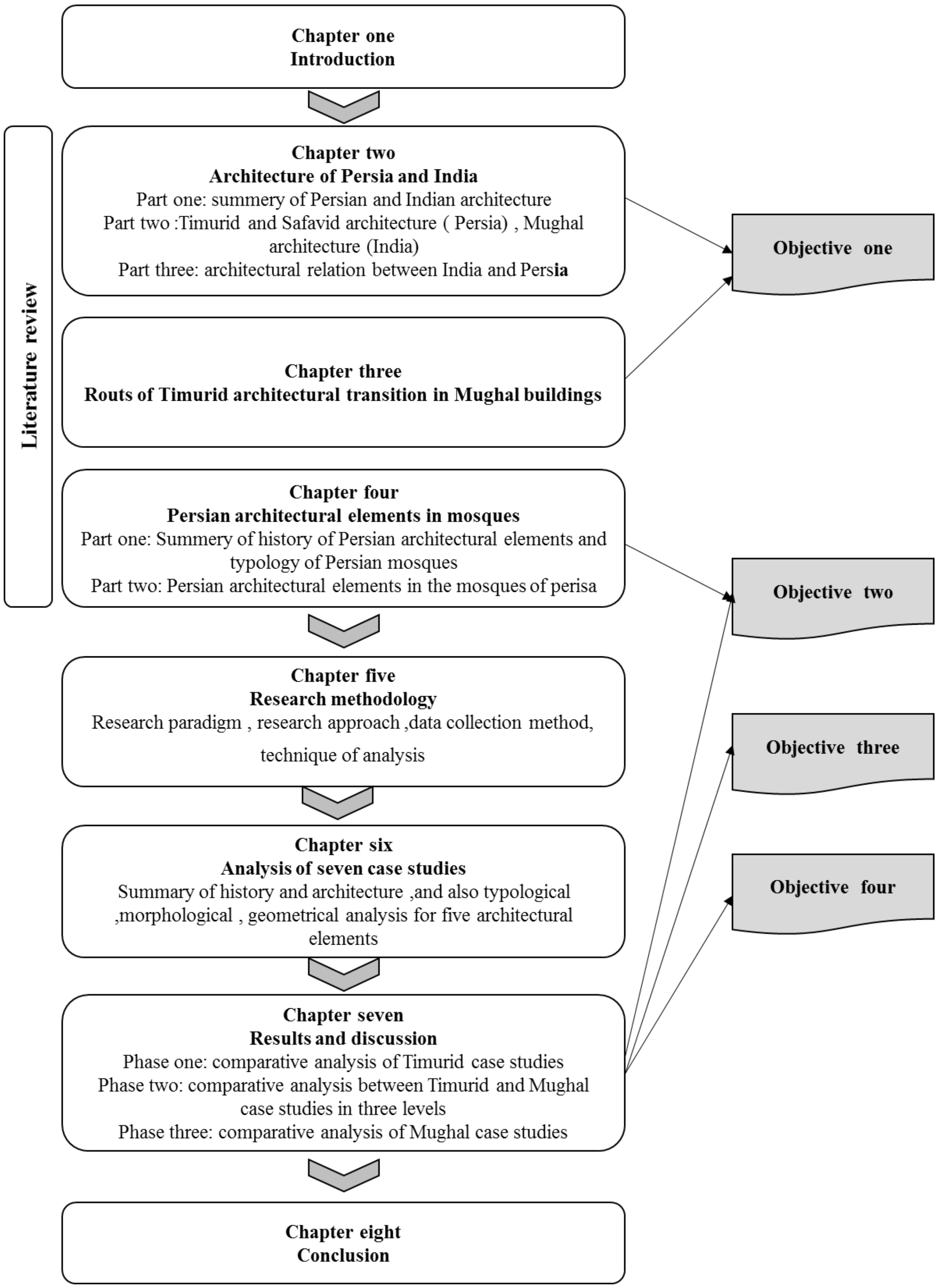


Figure 1.2: Overall representation of Research structure (Author-2011)

CHAPTER 2: ISLAMIC ARCHITECTURE OF PERSIA & INDIA

2.1. Introduction

This chapter is made up of three major segments. The first involves a brief study of Persian architecture after Islam, and covers the Persian Islamic historical periods, concentrating upon Timurid and Safavid architectures, continuing towards Indian Islamic architectural periods, with emphasis on Mughal architecture. The final section reviews the architectural relationship between Persia and India after the arrival of Islam up until the Mughal period.

2.2. Islamic Architecture

Islamic architecture encompasses a wide range of both secular and religious styles from the founding of Islam to the present day. When the Arabs spread Islam to other countries. They eschew from imposing their own culture and they left the other nations to their own devices in the development of their newly adopted faith. Islamic architects first utilized these native architects to build mosques, which lead them to eventually developing their own respective adaptations. What is today known as Islamic architecture originated from similar existing structures in Roman, Byzantine, and Persian lands conquered by the Muslims in the 7th and 8th centuries (Krautheimer, 1986). Moreover, in each region touched by Islamic civilizations, it was determined that they developed their own Islamic architecture based on Islamic principles and native architecture, such as Persian Islamic architecture, Indian Islamic architecture, and Turkish Islamic architecture (Hillenbrand, 1994).

2.3. Islamic Persia

The historical region which was called Persia was an independent kingdom, extending from the Caspian Sea in the north, to the Indian Ocean in the south, and from Afghanistan and Russian Turkestan in the east, and Mesopotamia, Kurdistan, and Armenia in the west (Ross, 1931). Figure 2.1. shows Persian architecture both before and after Islam throughout time.

Persian architecture maintained its continuity despite frequent retardation or diversions by internal conflicts or foreign intrusion, and attacks and invasion by different enemies, such as powerful foreign rulers – Seljuk Turk, Mongols (Illkhanid) and Timurid. They took over and assimilated the essence of the art and architecture with the spirit of the Persians. Looking back, the continuity of Persian architecture remains, and is easily discernable(Ardalan, Bakhtiar, & Nasr, 1973; Pope, 1965; Stierlin & Stierlin, 2002).

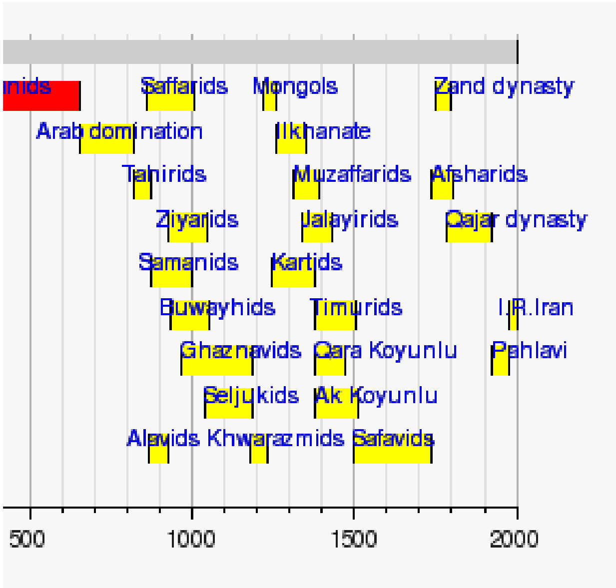


Figure 2.1: Persian dynasties through time (before and after of Islam) (source: http://en.wikipedia.org/wiki/History_of_iran)

2.3.1. Overviews of Persian Islamic Architectural Periods

As previously mentioned in Table 1.1 of the previous chapter, there are different views of architectural historians regarding the Persian Islamic periods. The dominant view is that Persian Islamic architecture comprised five main periods: Early period (623-1071AD), Seljuk (1071-1194AD), Illkhanid (1256-1335AD), Timurid (1370-1526AD), Safavid (1502- 1736AD) (refer to Figure 2.2).

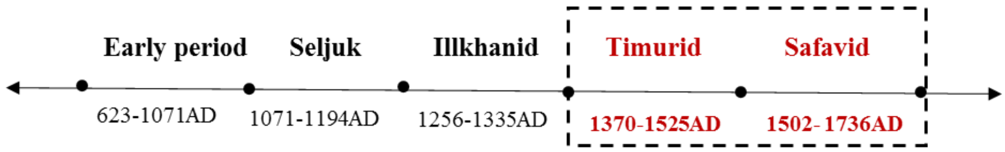


Figure 2.2: Islamic Persian historical period (Author-2011)

2.3.2. Early Period (623 – 1071 AD)

The most significant cultural change in the Persia was the recognition of Islam; those who introduced the new religion to the Persians possessed no distinguished background in the art and architecture; as a matter of fact, Persia was one of the areas where Islamic architecture developed and flourished (Ardalan et al., 1973). Early Persian Islamic architecture was developed based on the integration of pre-Islamic Persian and Arabic architecture such as:

- High attention to Islamic functions (mosques) by integrating the Arabic model (hypostyle) and Sassanid fire temples (domed chamber).
- Low attention to interior decorations –the absence of sculptures and paintings.
- Stretched in plan rooms, with cylindrical or domed chambers (Moradchelleh, 2010; pirnia, 2001; Pope, 1965).

2.3.3. Seljuk Architecture (1071 – 1194 AD)

The Seljuk was Persianate in nature and Turkic in origin, and slowly conquered Persia over the course of the 11th century. The dynasty had its origins in the Turcoman tribal confederations of Central Asia, and marked the beginning of Turkic power in the Middle

East. They established a Sunni Muslim rule over parts of Central Asia and the Middle East (Britannica, 2007; Petersen, 2002). During the 11th century, Persia produced a constellation of poets, philosophers, mathematicians, astronomers, physical scientists, historians, geographers and lexicographers; in comparison, Europe was still in the dark ages (Pope, 1965).

Seljuk architecture is characterized by the rapid transmission of ideas and forms. During this period, many characteristic forms of Persian Islamic architecture became common everywhere; a courtyard with four *ivans* is one of them (Petersen, 2002).

Courtyard with Four *ivans*: The open space of the courtyard is of fundamental importance in Persian architecture, and governs the concept of all types of building. The monumental *Ivan* polarizes the space of the courtyard. This distinctively Persian architecture is derived from the Sasanian (the last Persian period before Islam) royal hall. The four Ivan emphasizes the axes of the place of worship and the principal *ivan*, which leads to the hall containing a *mihrab*, is large, and often flanked by a pair of minarets, indicating the direction of prayer towards the southwest (Pope, 1965; Stierlin & Stierlin, 2002).

2.3.4. Illkhanid Period (1256 – 1335 AD)

The Mongol invasions, started by the ferocious Genghis Khan in 1218, was one the most tragic episodes in history. Whole provinces were depopulated by savage massacre, cities obliterated, and libraries consumed in the campfires of the barbaric invaders. Illkhanid was a breakaway state of the Mongol Empire (1206-1368AD), which was ruled by the Mongol House of Hulagu King. It was established in the 13th century, and was based primarily in Persia from their capital of Tabriz, as well as neighboring territories (Amitai, 2007; Atwood, 2004; Pope, 1965).

Illkhanid rulers adopted Persian culture, and were enthusiastic patrons of architecture, instituting large-scale building campaigns (including the foundation of the new royal city of Sultaniya-next capital of Illkhanid), establishing mosques and charitable institutions throughout their territories. The sum of these qualifies, when combined with Persian nationality and aesthetic traditions, ultimately resulted in 14th century architecture of powerful scale and sumptuous ornaments. The architecture of the Illkhanid Mongols is closely dependent on its antecedents, maintaining a coherent development from previous Seljuk styles and techniques (Pope, 1965).

2.3.5. Timurid Period (1370 – 1526 AD)

2.3.5.1. History

The Timurid dynasty was a Sunni Muslim dynasty of Turco-Mongol lineage that ruled over modern-day Iran, Afghanistan, much of Central Asia, as well as parts of contemporary Pakistan, India, Mesopotamia, Anatolia, and the Caucasus (see Figure). Timur (Tamerlane) founded the dynasty in the 14th century. The Timurids lost control of most of Persia to the Safavid dynasty in 1501, but members of the dynasty continued to rule parts of Central Asia and India, which are sometimes referred to as the Timurid Emirates(Britannica, 2007; Manz, 1999; Stierlin & Stierlin, 2002; Subtelny, 2007).

Timur the Lame or Tamerlane was of Turkish /Mongol stock on his father's side, belonging to the Barlas tribe and had converted to Islam. Timur conquered Transxiania and proclaimed himself ruler with a gold crown in 1370 A.D. Timur wanted to expand his territory in the direction of Persia since the collapse of the Mongols, and proceeded to overthrow the sultanate of Delhi and looted the city for three days, ending its prosperous reign (Stierlin & Stierlin, 2002).

After much wrangling over the succession issue, Timur‘s fourth son: Shah Rukh, took the throne (1377_1477AD), and was the founder of the Timurid dynasty (refer to Figure 2.3.). In 1445AD, Shah Rukh had to put down a rebellion by his son Baysungur in Isfahan. Two years later, he died, and the empire was divided: Muhammad bin Baysunghur received west Persia, Abu'l Qasim Babur received Khurasan, and Ulugh Beg was awarded Transoxania and east Persia. The Timurid dynasty fell in 1500 under the heels of Muhammad Shaybani Khan, the head of the Uzbek tribe(Golombek & Subtelny, 1992).

Members of the Timurid dynasty and their Turko-Mongol supporters became acculturated by the surrounding Persian milieu, adopting Persian cultural models and tastes, and acting as patrons of Persian culture, painting, architecture, and music (Subtelny, 2007). On top of that, one of the main motives behind Timur's empire-building efforts was the desire to control the lucrative trade routes linking the east and the west. The growing volume of the trade between China and Europe under the Mongols reinvigorated the ancient Silk Road, which was the commercial highway already in use under the Romans, and was the major artery of international exchange that Timur decided to build his capital (Stierlin & Stierlin, 2002).

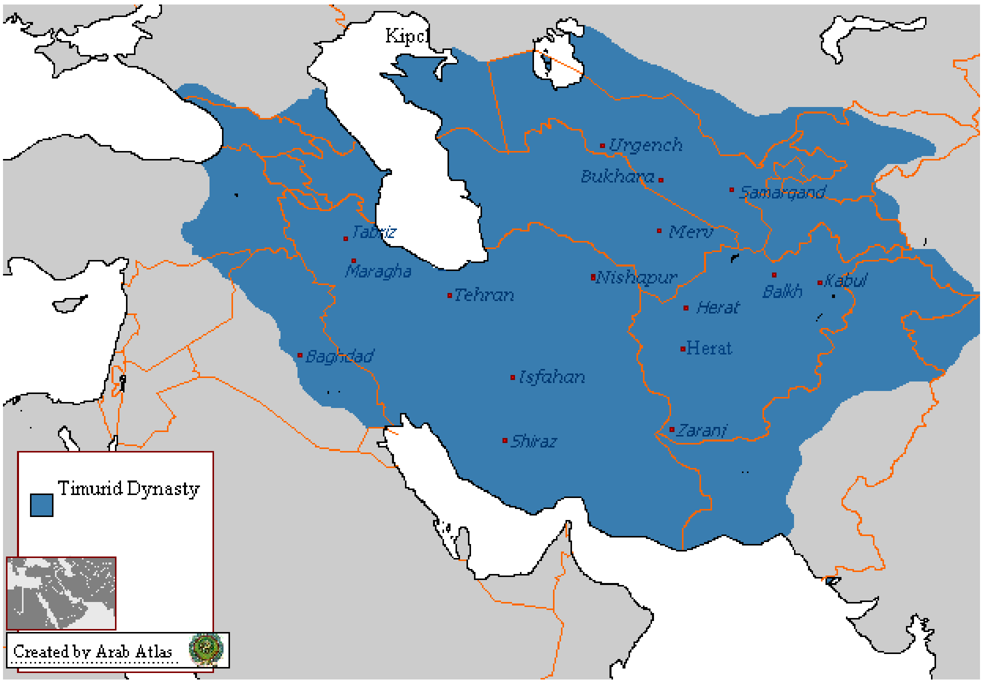


Figure 2.3: Timurid empire map (created by Arab Atlas)

2.3.5.2. Architecture

This dynasty's architectural legacy is rooted in its history as an expansive empire that drew on formalistically and centrally planned, highly symmetrical Persian architectural structures and typologies, while integrating reinterpreted architectural elements; mostly decorative, from Central Asia (as east Persia in Timurid dynasty). This was accomplished under the direction of Central Asia's conqueror, Timur, and his successors, Shah Rukh, Ulugh Beg, Baysunghur and Abusaid, who were all enthusiastic exponents of Persian culture, and presided over veritable Golden Age that saw all of the arts, including the arts of the living, reached new heights of perfection (Pope, 1965).

Functional characteristics:

- **colossal scale:** Timurid architecture is remarkable first for its colossal scale, as most of the building was based on Seljuk forms and construction, but took a new scale and magnificence thanks to the domination of Mongol personalities (Pope, 1965)(see Figure 2.4.a).

- **Complex building:** Throughout east Persia (Transoxania , Khurasan ,and Afghanistan), some 250 building from the Timurid period survived; these building were inspired within a coherent urban plan, mosque, *madrassa*, library, gardens, caravanserai, perhaps even a tomb and an associated sanctuary, and may be grouped together in an architectural complex (Stierlin & Stierlin, 2002)(see Figure2.4.b).
- **Geometry:** Exploiting the geometry and variation in the design of different buildings with centrally planned, highly symmetrical features (pirnia, 2001)(see Figure2.4..c).
- **Extroverted building:** Increase the use extroverted plan for funerary building, such as Shah-i-Zinda complex, most of them possessing a rectangular plan with discontinuous double-shell (pirnia, 2001)(see Figure2.4.d).

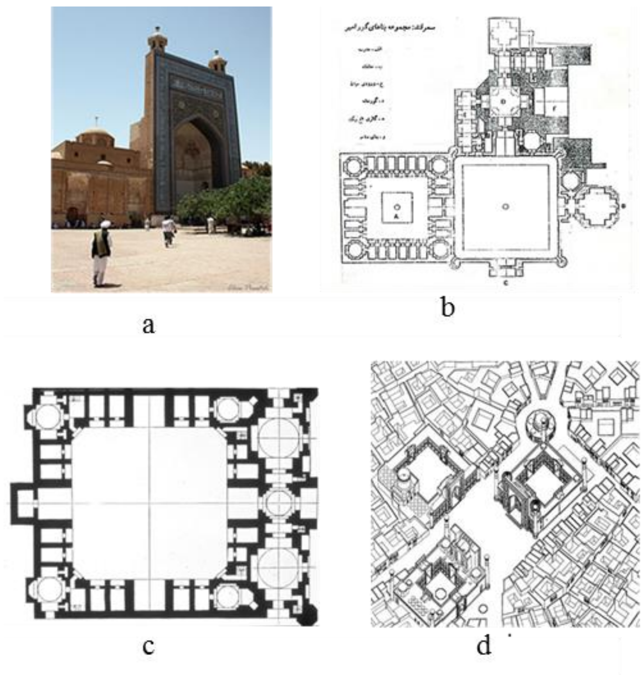
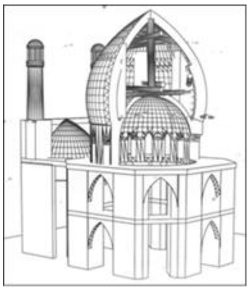


Figure 2.4: a)Torbat jam tomb (Author-2011) , b) Gur Amir tomb (O'Kane, 1982) , c) Ghiyacieh *madrasaa* (pirnia, 2001) , d) Rigestan squraure (pirnia, 2001)

Structural characteristics

- **Dome technique (**discontinuous double shell)**:** Timurid spared no expense in giving his great mosque an unrivalled splendor instead of being fitted into a dense urban fabric. Since a dome that was tall enough to be effective from the outside would result in an uncomfortable space, the Timurid architects built a second lower shell inside the structure (Stierlin & Stierlin, 2002)(see Figure2.5. a) .
- **Exploiting the novel arches** for vaults and domes that are more durable and suitable for vast and high bays (pirnia, 2001).
- ***Squinch*-net vaulting:** is one of the most important Persian Islamic architectural innovations in the Timurid era, and it appears to have evolved out of experiments with transverse vaulting over rectangular spaces. The spatial impact of this technique is the creation of open interior space through the minimization of supportive walls and piers(See Figure 2.5.b)(Golombek et al., 1988).



a

b

Figure 2.5: a)Double dome(pirnia, 2001), b) *Squinch*-net vaulting in Ghiyasiyya madrassa (Fletcher, 1961; O'Kane, 1976), revised by

Ornamental characteristics

Timurid architecture is remarkable for the quality and richness of their decoration, which covered façade, arched courtyard, minarets, *ivans*, *pishtaqs*, and domes.

Stierlin Stierlin (2002, pp. 78,79) mentioned some of the most ornamental features of Timurid architecture that is comprised of:

- **Geometry:** All of this ornament, drawing on geometry, floral shapes, and writings and on the principle of rhythmical repetition, is meticulously organized according to the laws of symmetry and duplication (see Figure 2.6.a).
- **Ceramic mosaic:** The technique of ceramic mosaic soon became widespread entire *ivans* and *pishtaqs* were covered with floral motifs. The use of polychrome ceramic becomes widespread, and new bold forms started to appear.
- **Molding:** Moldings are edges and the arches of *ivans* or the *muqarnas* that encompasses *squinches* and the bases of domes. The design was unified while fully exploiting a variety of motifs (see Figure 2.6.b).
- **Multiplicity of technique** a multiplicity of technique includes brick, glazed surfaces, mosaics, pierced screens, and sculpture friezes.
- ***haftrangi* (seven colors) technique:** *haftrangi* (seven colors) is a type of tile. By exploiting it, an architect could draw attention to particular zones of their design: not only *ivans*, but the spandrels of arches on façades or in the courtyards displayed floral motifs.

Figure 2.6: a)Geometry in ornamentation in Goharshad mosque b) molding in Goharshad

2.3.6. Safavid Period (1502 – 1736 AD)

2.3.6.1. History

The Safavid dynasty, which ruled from 1502 to 1736, is the first native dynasty since the arrival of Islam (see Figure 2.7.). Under the Safavids, Persia experienced an age of greatness that lasted for two hundred years. It was the last rise of military and political power of Persia, and was a period of national unity and economic growth (pirnia, 2001).

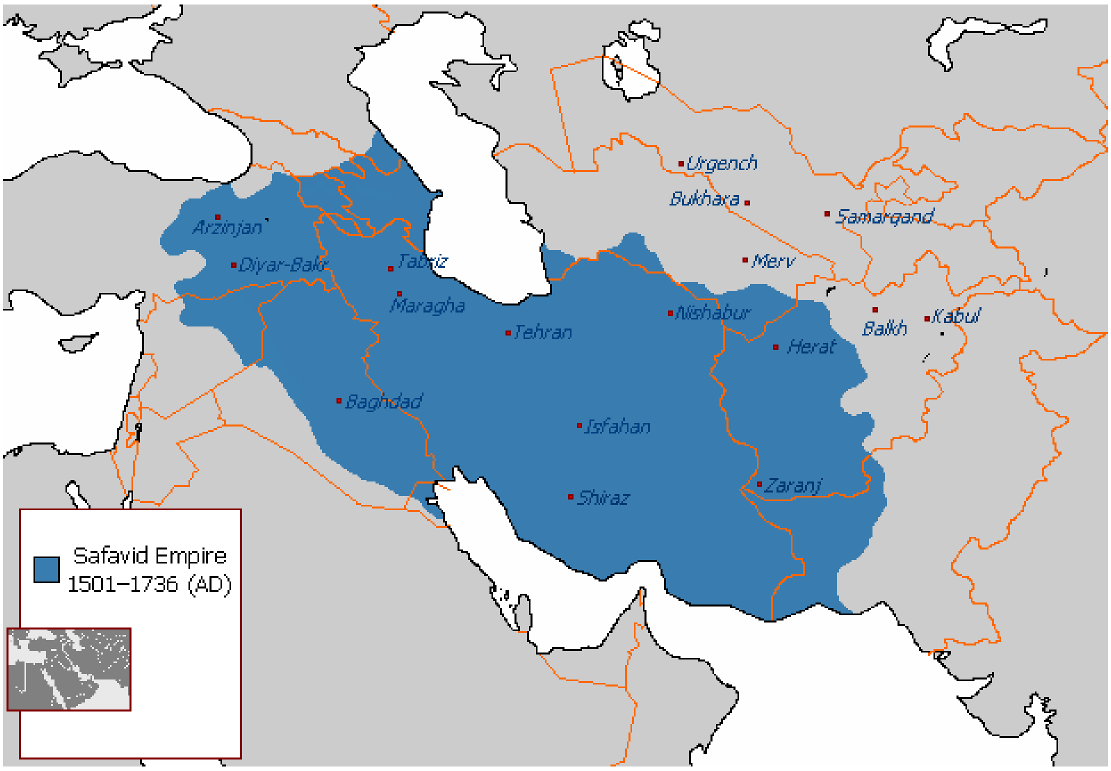


Figure 2.7: Safavid empire map (created by Arab Atlas)

2.3.6.2. Architecture

Architecture reached a rare level of perfection. Painting and the arts of the book (miniature, painting, calligraphy and binding), ceramics, the production of carpets, and fine jewels made Persia the subject of admiration of Europe. The Persian style was widespread throughout China and the Near East, and "Persian taste" was looked to be both distinctive and novel (Stierlin & Stierlin, 2002).

Under the reign of Shah Abbas I (1589-1627), the great period of Safavid architecture starts to open up. He initiated a new period in Persian Islamic architecture where the rich, sensationally colored, and imaginative details developed by his predecessors became unified into one serene and meaningful ensemble of immense scale and grandeur. Although marked by no great structural innovation , and certainly not Persia ‘s most supreme period , this architecture represents the culmination and final expression of Persian Islamic architecture.(Pope, 1965).

Functional characteristics:

- Huge attention is paid to urban planning, with city centers being developed around large squares enclosing principal mosques and palaces.
- Large civil complexes, including sacral buildings and bazaars.
- Simplified designs in most buildings, with the spaces being more square or rectangular.
- Using the simple geometry, fragmental forms, and lines.
- Using identical sizes and elements to construct a building (pirnia, 2001).

Structural characteristics

- Due to the short time required along with the decrease of the number of skilled architects, the quality of constructed building declined, and became unstable.
- Using varied types of domes and vaults, especially discontinuous double-shell domes, such as Masjid -i-Shah and Chahar Bagh madrassa. (pirnia, 2001).

Ornamental characteristics

- During this period, architects preferred to use *haft_rangi (*seven colours) tiles instead of the mosaic faience. For example, the enamel tile that covers the whole interior of the Masjid_i_Shah was *haft_rangi* tiles, which makes it inferior to the mosaic faience of the preceding centuries, or even to its own outer portals (pirnia, 2001).

2.4. Islamic India

India nurtured various cultures in ancient times. Along with literature, fine art, music, dance and drama, architecture, in all of its grandeur, rose to great heights (Kamiya, 1996). Geographically, India is fairly well defined, with the Himalayas to the north isolating it from the rest of Asia, whilst the Indian Ocean surrounds the country to the south. Within this vast area, there are many regions, each with its own languages, traditions, climates, and environment, varying from the cool mountains of Kashmir to the tropical heat of the Deccan (Petersen, 2002).

James Fergusson(1972b),the architectural historian, analyzed Indian architecture for the first time in his book; History of Indian and Eastern Architecture, Fergusson recognized two types of architecture: Architecture of Intellect, with the Parthenon in Greece as its ideal, and Architecture of Emotions, with the Halebid Temple in India as the best of this form. He added that the forms of architecture in the world lie between these two extremes. If there is something that could be referred to as 'complete architecture', it should exist somewhere between these two monuments.

India differs from other parts of the Islamic world, as it does not share the Roman and Sasanian traditions of the Middle East and North Africa, instead, it has its own complex history, which includes many different religions, cultures, and ethnicities(Petersen, 2002).

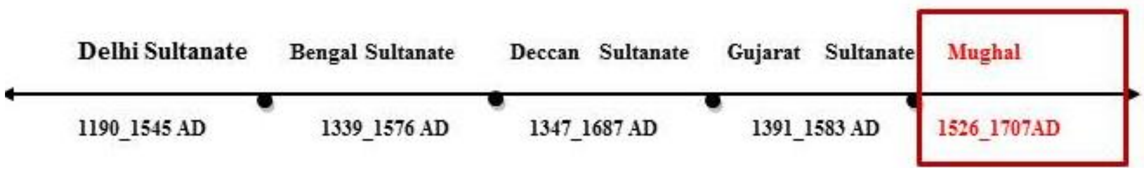


Figure 2.8: Islamic Indian historical period (main styles) (Author-2011)

2.4.1. Overviews of Indian Architectural Periods

Muslim traditions in India display both the greatest complexity and independence. Its complexity is evidenced by the five traditions: Delhi sultanate, Bengal sultanate, Deccani sultanate, Gujarat sultanate, and Mughal. Satellites of Delhi sultanate were the kingdoms of Jaupur and Malwa(see Figure2.8.) (Pereira, 1994). Moreover, Fergusson (1972a, pp. 188,189) mentioned sub styles in Islamic India that comprised of, in the north, Ghaznavid(999-1151AD), Ghorid (1148-1215AD) and Jaupur(1394-1479), and Malwa(1401-1530) (sub style of Delhi Sultanate). In the south, Bidar (1347-1609), Bijapur (1490-1660), and Golconda (1512-1627). Two styles might be designated as bastard styles. The first of these is that of *Qudh* (1756-1847AD), while the other is the short-lived dynasty of *Mysore* (1760-1799AD); both being further removed from the influence of European vulgarity.

2.4.2. Delhi Sultanate Period (1190 – 1545 AD)

In the 13th century, the longest surviving Muslim empire was established by the Central Asian Turks in India, which was known as the Delhi Sultanate (Yarshater, 1991). During this period, a new technique of architecture-the architectural styles of Persia, Arabia, and Central Asia was utilized. The engineering features of these buildings were the domes, arches, and minarets. The palaces, mosques, and tombs built by the rulers possessed these features, which were blended with the features of indigenous architecture, which resulted in a new synthesis of architecture. This occurred because the Turkish rulers of Delhi utilized the services of local Indian craftsmen, who were very skillful and had already constructed beautiful buildings. In the buildings that came up, we find the simplicity of the Islamic structure, as well as the detailed sculptures and designs they made using their own indigenous structures. A middle path was followed in all their designs in the architecture during this period(Pereira, 1994).

2.4.3. Bengal Sultanate Period (1339 – 1576 AD)

Between 13^{th} – 16^{th} centuries, Bengal was erected into a separate kingdom to the east of India, more or less independent from central control. Two capitals; Gour and Malda, was adorned with many splendid edifices. This style is singularly picturesque, and displayed all of the features of a strongly-marked individuality of styles (Pereira, 1994).

2.4.4. Deccan sultanate Period (1347 – 1687 AD)

The first notable Indian style in the south was the Bahmani (Deccani sultanate) dynasty. First at Gulbarga (1347AD), and afterwards at Bidar (1426AD)(Fergusson, 1972a). The Deccani style was a peculiar harmonization between Hindustani and Mussulmani modes (Islam, 1970). The usage of vaults and domes are quite prominent. The difference of the architectural style were essentially enumerated from those mentioned above, and was marked by a grandeur of conception and boldness in construction, unrivalled by any edifices erected in India (Pereira, 1994)**.**

2.4.5. Gujarat sultanate Period (1391 – 1583 AD)

The western Indian style adopted by the king of *Gujarat* during their period of independence (1396-1572 A.D.) was richer and more varied than that of *Jaupur*, though hardly so original or marked by such individually, from the architecture of the *Hindu* and *Jains* (Pereira, 1994).

2.4.6. Mughal Period (1526 – 1707 AD)

During this century, the Muslim world saw the rise of three great empires that constituted the most active, the most articulate, and the most closely-knit segment of the Muslim community. The Ottomans established themselves in Western Asia, and later penetrated Eastern Europe. At the same time, the Safavid empire was established in Persia, while the Chaghtai Turks swooped into the sub-continent and founded the Mughal Empire (Ashe, 1881). The Mughal Empire was the last of the great Islamic Indian empires, and also was one of the largest centralized states known in pre-modern world history. By the late 16th century A.D., the Mughal Emperors held supreme political authority over a population numbering between 100 and 150 million, and lands covering most of the Indian Sub-continent (3.2 million square kilometers) (refer toFigure 2.9.)(Richards, 1996).

Figure 2.9: Mughal empire map("www.wikimedia.org,")

2.4.6.1. Mughal architecture

The most universal of the Indo-Muslim styles is the Mughal; the mode of the Muslim architecture prevailing in the subcontinent coalesced into a pan-Indian style (Pereira, 1994). Of all the architectural styles created under the patronage of the various Muslim dynasties in India that of the Mughal was the most universal, successful, and widely influential. In reviewing the whole of Mughal architecture, we can discern the main formative phase; that of Akbar and Shah Jahan. Shah Jahan‘s enormous building programs also encompassed a considerable number of mosques. His was in fact the golden age of Mughal mosques (Koch, 1991b).

Mughal architecture created a supremely confident style by synthesizing the most heterogeneous elements, Timurid (Persian), Indian, and European. The superregional character of Mughal architecture sets it apart from earlier Islamic architecture of the Indian subcontinent, and gives it a universal appeal. At the same time, Mughal architecture was not strictly dogmatic, and remained flexible towards regional conditions and buildings traditions (Koch, 1991b).

According to Pereira(1994) and Koch (1991b) Mughal architecture can conveniently be divided into two phases:

- The *early Mughal phase* (1526-1605), covering the reigns of three emperors, Babur, Homayun and Akbar, climaxing under the latter. All the styles that will form the Mughal synthesis interacted with each other during this period.
- The *high Mughal phase* (1605-1707), covering the reigns of the emperors Jahangir, Shah Jahan, and Aurangzeyb, and attaining its zenith under Shah Jahan. The Mughal synthesis and its various components in balance, come into being, and encompass the Indian subcontinent.

2.4.6.1. Mosques of Mughal architecture

Due to the research focusing on Mughal mosques, the mosque pertaining to this period needs to be explained in detail. Despite the inherent differences in general forms of certain mosques (because of vernacular traditions in India), the Mughal mosques have a universality that is recognizable in all mosques, and are oriented in the east-west direction, with the *qibla* on the west side, and the main entrance generally on the east (Bunce, 2008; Frishman & Khan, 2007).

Pereira (1994, pp. 230,231) summarized the classification of Mughal mosques in three types based on the view of Bunce (2008) &Koch(Koch, 1991b):

Firstly, according to the main blocks of the mosques plan, two groups, mainly Hall mosque (The indispensable hall or sanctuary) and Cloister mosque (The cloister always combined with a hall).

Secondly, according to their stylistic phases: early and high.

- Early phase can be divided into four types (The first three belongs to the hall and cloister categories, while the fourth is exclusively from the hall category; Delhi (sultanate), Timurid, Jaunpur, and Kashmiri (sub East Indian style before Mughal period).
- High phase: crystallized into two clear types, and developed other miscellaneous ones. Two types were determined by their functions, public or private - assigned to them by imperial patronage - as the imperial mosque and the imperatorial oratory.

Thirdly, comprehensive classification can be established morphologically based on four considerations (this type of Mughal classification was used in this research).

- Whether or not the sanctuary façade has *Pishtaq*

- Whether or not a cloister is attached to the sanctuary
- Whether or not a cloister is given ,a sanctuary *Pishtaq* also
- What the number of the (transverse) aisles and longitudinal) bays. the last question is easily answered common aisle-bay combination are 2*3, 2*5 , and 2*7 ; uncommon ones are 1*5,2*11,3*7 ,and 3*9.

The criteria gave us four groups of mosques, presented in Figure and Table C-2 in Appendix C:

1. Those with no sanctuary *pishtaq* and no cloisters, a common aisle-bay combination is 1*3(Figure 2.10.a).
2. Those with no sanctuary *Pishtaq* but with a cloister. The number of *ivans* (some changed into gatehouse) can be one in theory (exclusive to the sanctuary), but it is actually three (adjoined only to the cloisters). 3*7 is a common aisle bay combination (Figure 2.10.b).
3. Those with sanctuary *Pishtaq* but with no cloister. The one *Ivan* interrupts the regular rhythm of the sanctuary‘s aisles and bays. Common aisle-bay combinations are 2*3, 2*5 and 2*7(Figure 2.10. c).
4. Those with both sanctuary *Pishtaq* and cloisters with *ivans*, the number of *ivans* in the entire mosque being two, three, or four. There is thus three sub styles: cloister mosque with two, three, or four *ivans*. Here, as before, the sanctuary *Ivan* interrupts the rhythm of the aisle and bays and in the cloisters. The *ivans* interrupts the continuity of the arcades or the cells. Common aisle–bay combination are 1*5, 2*5, and 2*7(Figure 2.10., d).

The first and second types include the imperatorial category, while the third contains miscellaneous mosque, and the fourth include the imperial mosques. Miscellaneous mosque forms are found in the first and fourth types as well. Further diversifying these types is the number of domes.

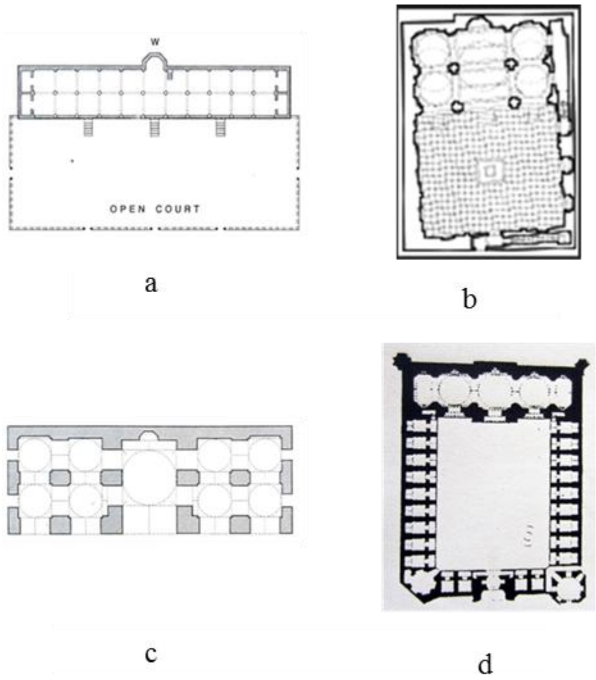


Figure 2.10: Mughal mosque types
a)First type-Shah Jahan mosque (Pereira, 1994),
b) Second type-Delhi Moti mosque(Pereira, 1994)
c) Third type-Kachpura Mosque (Koch, 1991b)
d)Fourth type -Khayr Al-Manazil Mosque(Pereira, 1994)

2.5. Overviews of architectural relation between Persia and India after Islam (before Mughal Period)

Before and after the advent of Islam, Persian architecture is heavily influential towards the structures of the Indian subcontinent. From the remote past, India and Persia were linked partly by a common ruling dynasty and by routes of trade and navigation, which served as a common ground for cultural activities and contacts. The cultural link between India and Persia was renewed with the advent of Islam (Gupta, 1988). The notable Persian style of architecture, which includes Seljuk, Illkhanid, Timurid and Safavid traditions, forms the basis of Indian architecture (Pourjafar & Taghvaee, 2004).

2.5.1Ghaznavids (999-1151AD)

Mehmud of Ghazna, after his accession to the throne in 998 A.D, succeeded in laying the foundation of a new empire in Sindh, the Punjab, and the northwest frontier of Pakistan. The Ghaznavids of India were among the first patrons of Persian poetry in the sub-continent (Mirza, 1975). Moreover, Ghaznavids is one of the first Islamic dynasties in India that had, without a doubt, important influence in Indian styles, and in fact formed the stepping stone by means of which the architecture of the west (Persia) was introduced to Indian styles(Fergusson, 1972b).

2.5.2. Ghorid Period (1148 – 1215 AD)

The Ghaznavids, however, were no longer in power, and another Muslim dynasty, the Ghorids, had disgorged themselves from the Hindu-Kush Mountains, conquered Ghazni, and captured Lahore. The Ghorids and the Sultans of Delhi who succeeded them were also great patrons of the Persian language. Under the Seljuks, Persia witnessed the most creative periods in the history of her art. During the reigns of Ghaznavids and later the Ghorids, the Seljuk art tradition penetrated the Sub-continent. The earliest mosque in existence in the sub-continent today is the Quwwat-ul-Islam at Lalkot, Delhi, which is a symbol of Seljuk tradition, and was begun in 1193 A.D. by Muhammad Ghori, who combined in his service all the finest spirits that Persian civilization could muster (Mill, 1990).

2.5.3. Delhi Sultanate Period (1190 – 1545 AD)

With the establishment of the Delhi Sultanate, Persia and Persian culture provided the dominant inscription for Indo-Islamic civilization. The Sultanate of Delhi soon became an important cultural and political center, with Persian serving as their court language

(Ahmed, 1999). The 13th and 14th century was a brilliant period for Persian literature and art, as Persian literature of that time was greater than the Arabic literature. Due to the origin and long history of the Delhi sultanate, they provided a unique opportunity for continual relation between India and its western neighbor (Persia) in all aspects, including language and literature, manners and customs, government, music, architecture, and religious organization (Bukhari, 1956; Choudhury, 1951; Irfan, 2002).

Many Persian architectural features were affected in Indian architecture since the establishment of the Delhi Sultanate in the 12th century A.D., such as tomb tower, domed chamber tomb, and four *Ivan* mosques. The first monument of the Delhi sultanate is the Qutb complex (1197AD), comprising the Quwwatul Islam mosque, the Qutb minar, and the Alai Darwaza (gate way), reflecting Persian concepts and origin: the four *ivan* courtyard mosque(Habib, 2002; Pereira, 1994; Pourjafar & Taghvaee, 2004; Stierlin & Stierlin, 2002). Another example is the mosque of Moḥammad Shah II (1325-51) in Begumpur as the only elaboration of the Seljuk-inspired mosque type developed earlier during the sultanate period, unlike later mosques, which represents a departure from Indian mosque planning, reflecting the developments in Seljuk architecture of Isfahan (Britannica, 1978; Hejazi, 1997).

The Delhi sultanate tombs appeared to have followed the Seljuk traditions as one of the main Islamic Persian period, in the form of domed chamber tomb and tower tomb. The domed chamber tomb of sultan Iltutmish (1236AD) and Multan tomb (1320AD) were one of the extent tomb structures to be constructed under the Delhi sultanate. The Multan tomb had dome corner turrets in an octagonal plan with *ivan*, and Quṭb Minar is similar to the Persian tomb towers like the Gonbad-e Qābūs (north of Persia) (Habib, 2002; Hasan, 1971; Hillenbrand, 1992; Jaffar, 1972; Tadgell, 1990, 1994; Yarshater, 1991).

The Muslim artisans brought art in India from Persia, for instance; the art of glazed tiles originated in Persia, mainly at Kashan, in 13th and 14th century A.D., and these blue tiles from there were copied and used for the construction of earliest mosques in India (Dikshit, 1969).

2.5.4. Deccan Sultanate Period (1347 – 1687 AD)

The Deccani rulers were mostly Shia Muslims, and were emotionally linked to Safavid Persia. There were extensive diplomatic relations between the Deccan kingdoms and the Safavid rulers. Shah Abbas I also arranged for a matrimonial alliance with the Qutb Shahi family. A Persian immigrant and a diamond merchant Muhammad Saeed (Mir Jumla) rose to a high position – that of Chief Minister - in Golconda (Islam, 1970).

The Bahmanid kingdom (as sub style of Deccan sultanate) in Hyderabad (1347-1518 A.D.) had strong relations with the Persians, which resulted in a fine taste for architecture. The most noteworthy of the existing monuments at Gulbarga (the capital of Bahmanid kingdom) are *Chand Minar* at Daulatabad and the *Madrasa* of Mahmud Gawan at Bidar, might be among the remaining edifices of importance. *Haft Gumbad* (seven domes) in Gulbarga, containing the tombs, should also be mentioned. The style of architecture of these monuments is mostly Persian (Gangler, Gaube, & Petruccioli, 2004; Mainstone, 2001; Pereira, 1994).

Bidar (sub style of Deccan sultanate)'s chief claim to architectural distinction is neither tomb and mosque but the great Madrassa of Mahmud Gavan .the Persian minster of Muhammad shah Bahmani III(1463-1482) is totally represented by Persian form was not to be favored in India(Hejazi, 1997; Mainstone, 2001; Pereira, 1994). It also distantly recalled the palace type represented by Timur's Shahr-I-Sabz. Also, they more clearly echo something of Bidar‘s synthesis between the imported tradition of *ivan* and *Talar* (big saloon) (Hejazi, 1997).

2.6. Summary

Islamic architecture that first came from the Arabian Peninsula were developed and expanded in diverse regions of the Middle East, North Africa, Central Asia, and the Far East. The architecture of all Islamic civilizations was formed based on the integration of indigenous architecture and Islamic principles. Two of these civilizations developed in India and Persia. Both of these regions had rich and powerful relationship before the coming of Islam (refer to Figure 2.11).

Persian Islamic architecture falls within many historical periods, mainly Seljuk, Illkhanid, Timurid and Safavid. Architectural features of the Timurids are well known for its novel and new architectural concepts and elements. With the Timurid renaissance, the architectural language was revitalized, as new buildings were set with grandiose urban plans. The Safavid architecture, marked by no great structural innovations, and certainly not Persia‘s most supreme period, were nonetheless representative of the culmination and final expression of Persian Islamic architecture.

Indian architecture after the arrival of Islam in India flourished during the Delhi sultanate in the north, Deccan sultanate in the south, Gujarat and Bengal sultanates in the west and east, and finally the Mughal sultanate in the whole of the Indian subcontinent. The Mughal architecture is the most universal of the Indo-Muslim architecture; the mode of the Muslim architecture prevailing in the subcontinent coalesced to form a pan-Indian style.

Persian architectural relations with India continued after the arrival of Islam in different Indian periods, such as Ghaznavids, Ghoranids, Delhi Sultante, Deccan sultanate, and ultimately, the Mughal period, where this relationship peaked.

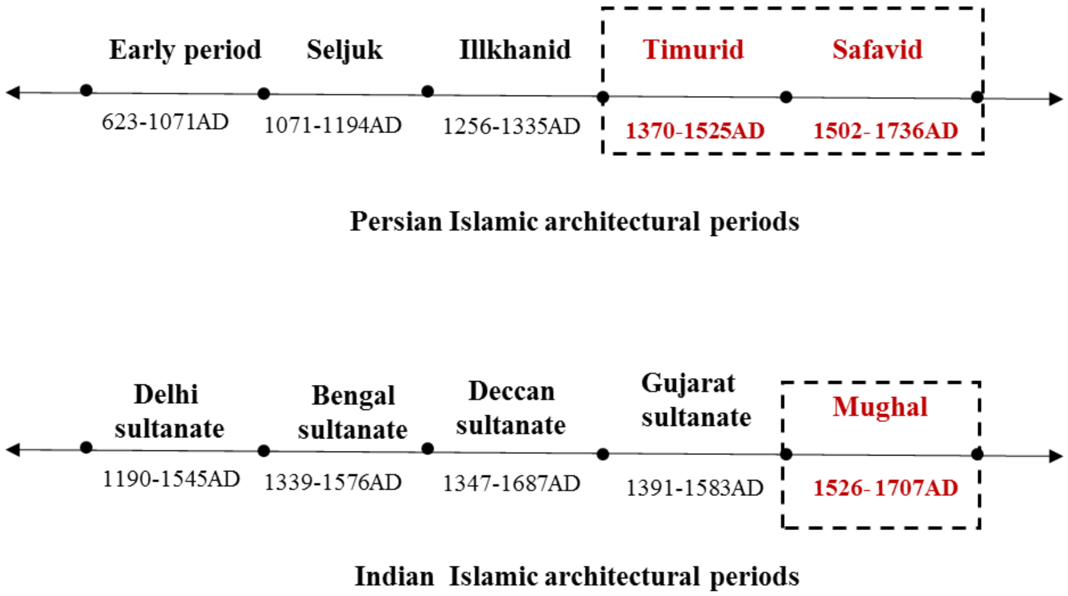


Figure 2.11: Islamic Persian and Indian periods (Author-2011)

CHAPTER 3: ROUTES OF TIMURID ARCHITECTURAL TRANSITION TO MUGHAL BUILDINGS

3.1. Introduction

The aim of this chapter is to focus on the first objective, which is to define and verify the routes of Timurid architectural influence in Mughal buildings of the Indian subcontinent with regards to Timurid (1370-1525AD) and Mughal (1526-1707AD) periods being non-concurrent. Due to the non-concurrence of Mughal and Timurid periods, this chapter explains how Timurid architecture transfers and influences Mughal mosques. The first section focuses on the relationship between India (Mughal period) and Persia (Safavid period) in all aspects in the 16th and 17th century AD, and then describes the influence of Timurid architecture instead of Safavid architecture in the Mughal buildings based on historical evidences.

3.2. Mughal and Persia

During the Mughal era, bilateral relations between Persia and India peaked in all aspects of life: so much so that it is called the "Golden Era" of the development of socio-cultural and political relations between the two countries (Pourjafar & Taghvaee, 2004).

In the 16th century, Persia witnessed the rise of the Safavid Empire, while India was contending with the corresponding rise of the Mughal dynasty. Both India and Persia were formidable powers under these respective dynasties. The relations between these two countries were made up of multiple facets, which included, among others, politics, diplomacy, culture, literature, trade, and religion (Islam, 1970).

3.2.1. Channels of Influence: from Safavid to Mughal

2.3.1.1. Persian Language

When the Mughals established their empire in India, the Persian language was the language they used; the Persian law and the Persian religion (Islam) were the law and religion they had opited, and Persian was also the official language of the administration. Even after the fall of the Mughal Empire, Persian continued to be the language of private correspondence among the educated classes, and formed the basis of Indo-Muslim culture (Mughal, 1974; Ziauddin, 2005).

2.3.1.2. Role of Persian Ladies in Mughal Court

The role of Persian women from the Safavid era in the Mughal Court was a major source of influence over the socio-political arena of Mughal life. Hamida Bano Begum, Nur Jahan, and her niece Mumtaz Mahal, the famous wife of Shah Jahan, were of prime importance in the view of the presence of many other Persian women who belong to Mughal Court, with their multidimensional capacities and status (Pourjafar & Taghvaee, 2004).

3.2.1.3.Persians in Mughal politics and administration

The Safavid Persians comprised of one of the most important groups of nobility at the Mughal Court and performed a vital role, as well as in Mughal India. Persians occupied not simply high offices, and their presence was pronounced at almost all levels of Mughal politics and administrations. It is worth noting that almost all of Jahangir’s and Shah Jahan’s prominent ministers were of Persian heritage (Islam, 1970).

3.2.1.4.Persian scholars and literary personalities

Throughout the Mughal regime, a great number of scientist, literary and cultural workers, scholars, political figures, and artisans from neighboring countries or from other areas migrated to different cities of India, many of them attached to the Mughal Court. However, the Persians from the Safavid period in this regard were undeniably important. Persian was the language used in the Mughal Court, and their ministers and other members of the nobility followed the example of Mughal Emperors' generous patronage towards Persian poets and scholars. The Mughal Emperors, especially Akbar, Jahangir, and Shah Jahan, assembled brilliant gatherings of Persian scholars and poets at their respective courts(Pourjafar & Taghvaee, 2004; Ziauddin, 2005).

3.2.1.5.Persian craftsman and artists

The cultural links between Persia (Safavid period) and India (Mughal period) are deeply rooted. These cultural influences are specifically noticeable in the form of visually significant objects, such as miniatures, architecture, calligraphy, coinage, bookbinding, carpets, jewelry, and pottery. From the reign of Humayun to Aurangzeb, about 110 people of excellence and quality, skilled artisans and other skilful persons from various cities of Persia in the Safavid era, like from the other parts of the world, visited the Mughal imperial Court as well as noble establishments with high expectations and anticipations (Ziauddin, 2005).

Persian artists from the Safavid dynasty, such as Abdus Samad of Shiraz, Mir Seyyed Ali of Tabriz, Faroukh Qalmaq, Muhammad Nadir Samarqandi, Mir Hashemi, and Mohammad Faqirullah Khan worked alongside their Indian colleagues in royal Mughal courts (Michell, Grube, & Grabar, 1995).

Table 3.1.shows the list of Persian architects and builders that migrated from Safavid to India in Mughal periods.

Table 3.1: List of Persian architects in Mughal period (Ziauddin, 2007)

No	Name	Position in India	Period of Migration
1	Ustad Shah Mohammad	Architect	Babur
2	Mirak Mirza Ghiyas	Architect	Babur
3	Amini Mashhadi	Designer/Decorator/Poet	Akbar
4	Rafiq Amuli	Architect	Akbar
5	Dost Muhammad (Khwaja Jahan)	Architect	Jahagir
6	Ali Esfahani	Architect	Jahagir
7	Mir Abdul Karim Mamuri Esfahani	Architect	Jahagir
8	Ustad Ahmad Esfahani	Architect	Shah Jahan
9	Ustad Hamid	Architect	Shah Jahan
10	Amanat Khan Shirazi	Architect	Shah Jahan
11	Ustad Isa	Architect	Shah Jahan
12	Ali Mardan	Architect	Shah Jahan
13	Mulla Ala-ul-Mulk Tuni	Architect	Shah Jahan

3.3. Mughal and Timurid Architecture

Even though the Mughal period (1526-1707AD) was a contemporary of the Safavid era (1524- 1736) , several scholars (Asher, 1991; Dale, 2004; Golombek, 1981; Habib, 2002; Hoag, 1968; Koch, 1991b; Pereira, 1994; Stierlin & Stierlin, 2002) indicated that , Mughal architecture was mostly influenced by the Timurid dynasty (1370-1525AD) more than Safavid architecture. For example, Koch (1991b, p. 15), in his book (Mughal Architecture: An Outline of Its History and Development, 1526-1858), cited that since the Mughals were direct heirs to the Timurids, the sustaining elements of their architecture, especially during the initial phase, was Timurid, and as such, a perfect symmetry of plan reflected consistently in the elevations , as well as complex vaults patterns.

The main question is what are the routes and channels of Timurid's influence in Mughal Architecture?

The non-concurrence of both the Timurid and Mughal period gave way to three assumptions with regards to the influence of Timurid architecture on Mughal buildings (refer to Figure 3.1.).

1) The first proposition is via Indian dynasties that were contemporaries of Timurid, including the Delhi Sultanate (1193-1554AD) and the Deccan sultanate (1347-1678AD).

2) The second one is directly influenced from Timurid dynasty in Mughal buildings.

3) The third one is influenced via the Persian period (Safavid) that is a contemporary of Mughal buildings.

In the first and third route, Timurid elements and principles have entered and indirectly influenced Mughal buildings via other dynasties in both Persia and India.

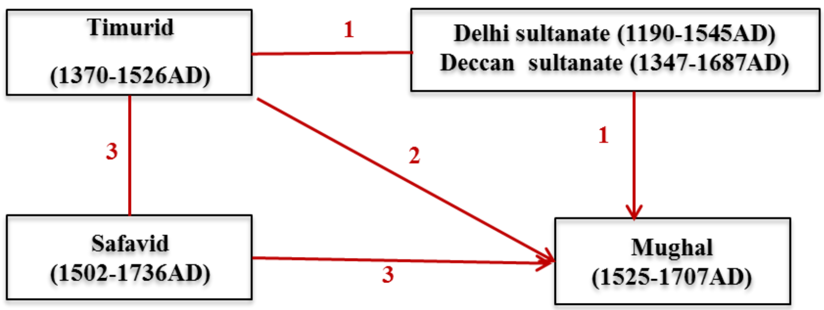
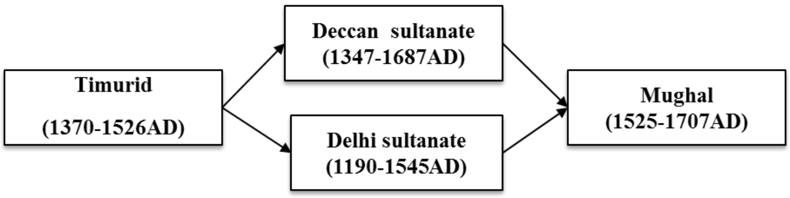


Figure 3.1: Propositions for Timurid architectural influence to Mughal buildings (Author-2011)

3.3.1. First Poposition (Timurid Influence in Mughal Architecture via Indian Architectural Styles)



After the advent of Islam, and with increasing multilateral relations between Persia and India, many Indian architectural styles were influenced by Persian architecture, such as the Ghorids, Ghaznavid, Delhi Sultanate, and the Deccan Sultanate (Ziauddin, 2005). Moreover, the Timurid Empire (1370-1526AD) was a contemporary of the late of Delhi Sultanate (1193-1554AD) and Deccan Sultanate (1347-1687 AD). Many historical evidence explained Timurid's influence on the Indian styles prior to the Mughal era (see Figure 3.2. A) Such as:

3.3.1.1. Timurid's Impact in Delhi Sultanate Architecture

Timuir, the founder of Timurid dynasty, conquered Delhi due to the weakness of the Empire. After that, some octagonal tombs were constructed based on the Timurid tradition by Firuz Shah (king of sultanate)(Brown, 1942). In addition, after Buber Shah (founder of Mughal empire), the Afghan Shir Shah Sur, who temporarily deported the Mughals from the Indian subcontinent, ruled from Delhi (1540-45), and ordered the construction of the Qal-ye Kohna mosque. The internal and externalities of the mosque are richly covered with red and white stones, some of which are inlaid in complicated geometric patterns, reminiscent of Timurid tile patterns (Asher, 1988; Yarshater, 1991).

3.3.1.2. Timurid‘s Impact in Deccan Sultanate Architecture

The Bahmani (sub style of Deccan Sultanate) shows clear evidence of Timurid influences. The earliest mosque in the Gulbarga (1358-1373AD) is one of the first in India to reflect contemporary Timurid (1370-1525AD) interest in the multi-bay prayer halls of the Jami-Masjid of Isfahan. This approach was certainly favored by the architects of Firozian Delhi, but its most original expression is the Jami Mosque of Golbarga (by Timurid architect ,Rafi of Gazvin) (Hejazi, 1997; Mainstone, 2001; Pereira, 1994).

Bidar’s (the sub style of Deccani Sultanate) chief claim to architectural distinction is neither tomb nor mosque, but is the great Madrassa of Mahmud Gavan. The Timurid minister of Muhammad Shah Bahmani III (1463-1482) is totally represented by the Persian form, which was uncommon in India. The form is a symmetrical four-*ivan* plan, with colored tiles and cruciform chambers and satellite domes on reticular *pendatives*, which are related to the contemporary Timurid work (Hejazi, 1997; Mainstone, 2001; Pereira, 1994).

3.3.1.3. Mughal and Indian Styles

Based on the studies of Habib (2002), Pereira (1994) and Koch (1991b), most of northern Indian styles influenced Mughal architecture. Mughal architecture borrowed extensively from the Delhi sultanate, Bengal sultanate, and Gujarati sultanate, and also some sub Indian styles (Sharqi, Malwa, Jaipur, Kashmiri and Rajasthan styles), as well as styles from abroad, such as Timurid, so much so that it has itself been defined as a synthesis of these foreign and indigenous styles (Habib, 2002; Koch, 1991b; Pereira, 1994)(refer to Figure3.2. B).

None of these historical evidences posits the fact that Deccan architecture has any influence over Mughal buildings, so it is possible that Timurid architecture influenced, and was transferred into Mughal architecture via the Delhi Sultanate styles (Figure3.2. C).

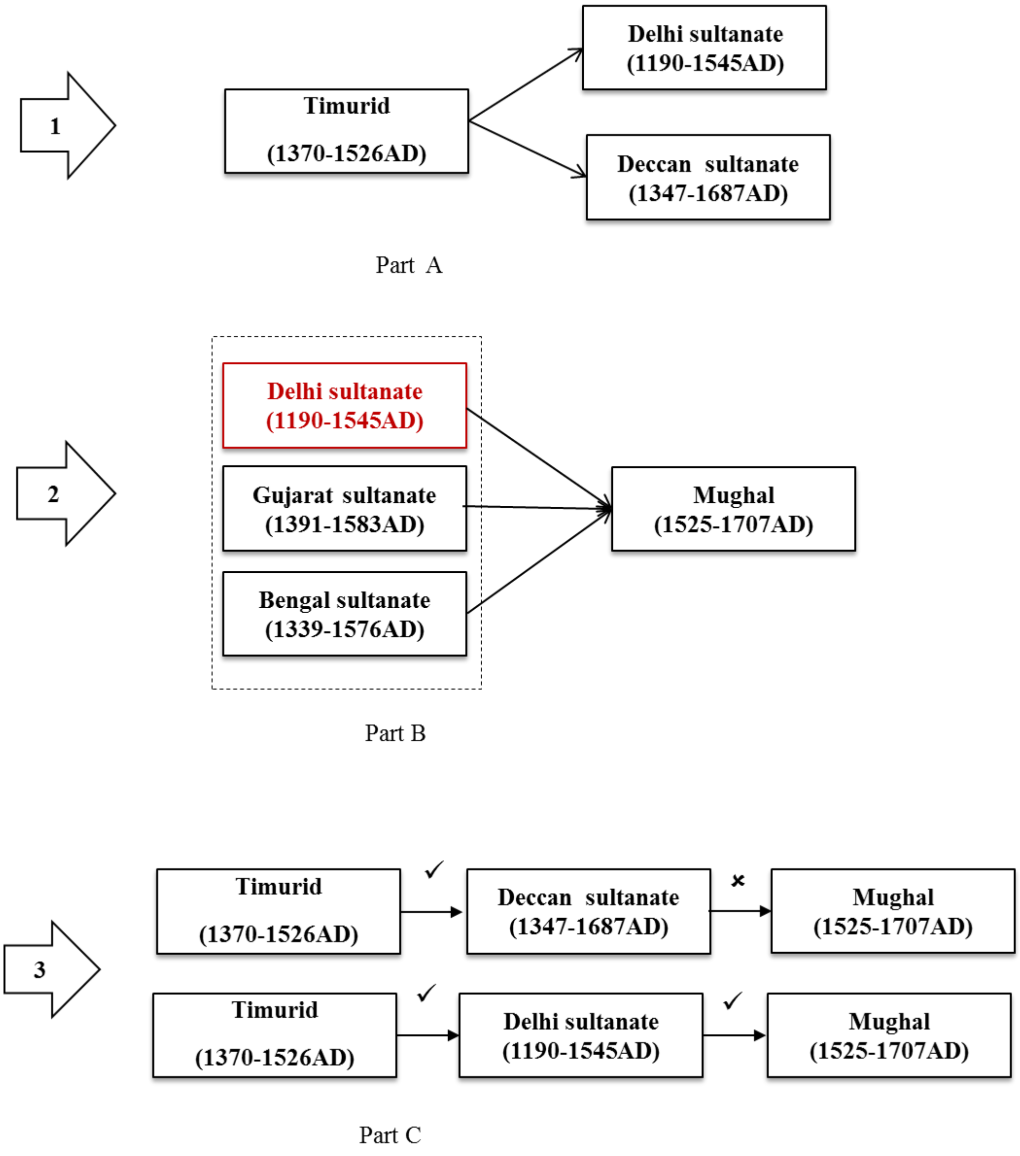
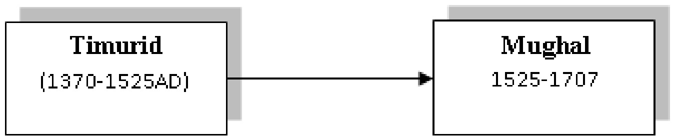


Figure 3.2: Results of first proposition of indirect Timurid influence via Indian style (Delhi Sultanate architecture) in Mughal buildings
A, Timurid influence in India (before Mughal).B, Indian influence in Mughal period
C, validity of Timurid influence in Mughal period via Delhi & Deccan sultanate (Author-2011)

3.3.2. Second Proposition (Direct Influence from Timurid to Mughal Architecture)



In the initial phase of Mughal architecture, the Mughals relied strongly on their already highly developed Timurid architectural heritage, but at the same time, they entered into creative dialogue with the local buildings' traditions and conditions (Koch, 1991b). These historical evidences show the direct Timurid influence upon Mughal architecture:

The founder of Mughal Empire -Babur-was originally a Timurid from the Uzbek region of Samarkand. He received help from the Safavid King-Shah Ismail I, and established himself first in Kabul, and then in Delhi and Agra (Hejazi, 2003). After coming to India, Babur ordered the construction of three mosques. It was too short time for the Mughals to familiarize themselves with the regional architectural tradition of India, in addition, he brought along with him Timurid architects who continued their works in the Safavid era, such as Ustad Mir Mirak Ghiyas of Herat, and Ustad Shah Muhammad of Khorasan (Khurasan and Herat are main art zones in Timurid era-author) (Habib, 2002; Pugachenkova, 1963).

The birth, rise, and fall of both Mughal and Safavid architecture happened approximately at similar times. Simultaneously, Safavid architecture did not form and developed well, and it was affected by Timurid architecture heavily, due to the power and wideness of Timurid architecture. Buber and Humayon ordered the migration of Safavid architects that were either Timurid architects that still worked for the Safavid dynasty, or were new Safavid architects applying Timurid elements and principles(pirnia, 2001; Stierlin & Stierlin, 2002).

Humayun, the second king of Mughal, defeated his enemies and stayed in Persia for eleven years, and he was highly interested in Persian literature and art. Several Persian poets and scholars from the Safavid era later migrated to India, while Humayun returned to India. These architects still used Timurid elements. Timurid elements were soon merged with local buildings, particularly the facets of buildings and architectural decorations. The most important building of Humayon's period is the mosque at Kachpura (1530-31AD), which influenced Timurid mosques at the Samarqand (Koch, 1991b).

Figure 3.3: Humayon tomb, Delhi (Author-2012)

The principles trend in the first phase under Babur and Homayun were successfully merged in the great architectural synthesis under Akbar, together with other Indian sources (Koch, 1991b; Pereira, 1994). The best example of Timurid influence is the tomb of Humayun (see Figure 3.3.), which is a synthesis of creativity developed from Timurid ideas *Chahar Bagh*[1], *Hasht Behesht*[2]-and local traditions. This building was designed by Sayyid Muhammad and his father , Mirak Sayyid Ghiyath –Timurid, who were architects active in Herat during the Safavid period (Koch, 1991b).

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[1] Or called Chahar Bagh, it division in four parts as a cross or perpendicular streets has been used in gardens and yards of tombs and palaces according to importance of geometry and application of rectangular plan(pirnia, 2001).

2 hasht bihisht or Chahar taghi or noni partite plan is division four intersecting constructional lines into nine parts, comprising a domed chamber in the corner, rectangular plan(pirnia, 2001)

The mosques of Akbar‘s period showed the variety of styles as characterized by the funerary and residential architecture. The earliest phase continues the local tradition, while embellishing it with Timurid ideas, such as Khay-al Manzil mosque (1561-1562), which is a combination of Delhi type of Shir Shah mosque with Timurid influence (the courtyard enclosed by three double-story wings). Another example is the Dargah mosque, which is entirely in the Timurid idiom (Timurid characters are domed chamber proceeded by high *pishtagh*) (Hillenbrand, 1976).

3.3.3. Third Proposition (Timurid Influence in Mughal Architecture via Safavid Architecture)

The cordial relation between the Safavid and Mughal empires was initiated from the time of Babur, the first Mughal king, and Humayon (the king employed a great number of Safavid -Persian artists after returning from Persia). Moreover, many Persian politicians and administrators were employed by the Mughal court, and were vital to the day-to-day operations of the Mughal Empire (Islam, 1970).The influence of Safavid architecture in Mughal buildings can be found in the high phase, especially under Jahangir and Shah Jahan, as detailed below:

Jahangir followed a more introverted phase of revision, reflection, and adaption. The main function was to test and further develop selected Akbari solutions, rather than explore new foreign sources. Safavid influence did, however, gain an importance, such as using the Maryam al-Zamani mosque (other name is Beygum Shahi mosque-author) at Lahore, which was duly influenced by Timurid and Safavid components (Koch, 1991b).

Under **Shah Jahan**, Mughal architecture reached its apex and second climax. This region is marked by the heavy influence of indigenous styles (Habib, 2002), however, it was also blended with new and foreign types of buildings, such as the bazaar of the red fort of Shah Jahanabad, which was ultimately traced back to its Safavid roots. Moreover, most of the Safavid architects that migrated to India were from Shah Jahan's period (Stierlin & Stierlin, 2002; Ziauddin, 2005).

The earliest discontinuous double dome type is that of Gur-i-Amir. Its noble progeny includes the mosque of the Imam (Shah) mosque in Isfahan, and the Taj Mahal in Agra. The double shell dome appears to have been a Timurid innovation (see Figures3.4.,3.5. &3.6.) (Stierlin & Stierlin, 2002).

The cruciform or four–*Ivan* mosque made its appearance in India during the sultanate period. Under the Mughal, it is first encountered in the region of Jahangir, but it become popular during the reign of the Shah Jahan, such as: Beygum Shahi mosque (Jahangir era) at Lahore (1611-14), and Wazir Khan mosque (1634-35), again at Lahore, the Jami mosque at Agra, and (Delhi) Shah Jahanabad (Habib, 2002).

Figure 3.4: Gur_i_Amir tomb - Timuird building(archNet)

Figure 3.6: Taj Mahal - Mughal building (Author-2011)

Figure 3.5: Mosque of the Imam - Safavid building (Pirnia,1998)

3.4. Summary

In short, despite the fact that the Timurid era was not a contemporary of the Mughal dynasty; the Timurid influence has become widespread and prevalent during the whole Mughal period (refer to Figure3.7.).

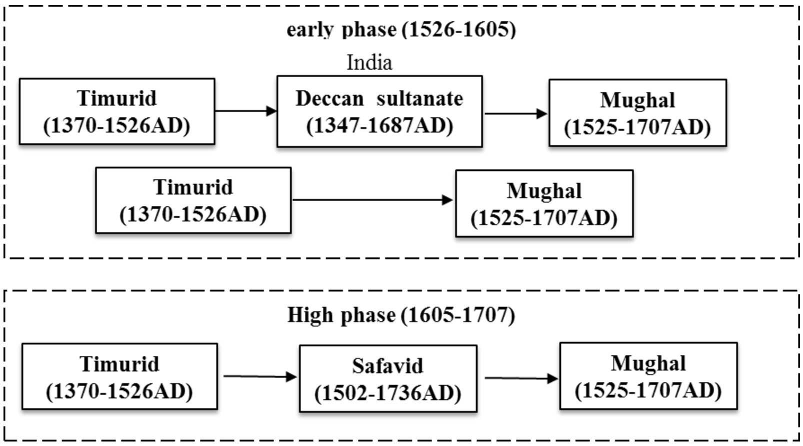


Figure 3.7: Distribution of Timurid influence directly and indirectly in Mughal architecture base on early and high phase (Author-2011)

In the early phase of the Mughal period, despite the good relationship between Mughal kings with the Safavid court, Timurid architecture was applied greatly in the early Mughal buildings due to two main reasons. Firstly, in the initial phase of the Mughal period, particularly Babur and Humayon had only a short amount of time to be familiar with indigenous Indian styles. Beside that the Mughal kings were interested and encouraged the migration of craftsman and architects from Persia (due to the fact that Babur was originally a Timurid, while Humayon was a long time resident of Persia). This migration continued in Akbar's era. Another reason is that the initial phase of the Mughal period was a contemporary of the early phase of Safavid dynasty, and the early Safavid period was completely influenced by Timurid architecture. Thus, Safavid architects and craftsman that migrated to India were either Timurid architects that still worked in Safavid dynasty, or were new Safavid architects that preferred to apply Timurid elements and principles, so that instead of Safavid architecture, its Timurid counterpart was transferred and influenced early Mughal buildings. The principle trend under Babur and Humayun were successfully merged in the great architectural synthesis under Akbar during the early Mughal phase.

Furthermore, among the Indian architectural periods that were influenced by Timurid architecture, only the Delhi Sultanate (not Deccan Sultanate) heavily influenced Mughal buildings of the early period, so that the first proposition (with omission of Deccan Sultanate) and the second one are valid during the early phase of the Mughal period.

In the high phase, the Mughal architecture reached the climax of development, and was heavily influenced by indigenous styles rather than foreign architecture. At the same time, Safavid architecture was in its climax of power and grandeur. The increase relations between Mughal and Safavid eras in every aspect such as politics, diplomacy, culture, literature, trade, and religion resulted in the use of Safavid architectural models in Mughal edifices. Safavid architects and craftsman that migrated to the Mughal court applied the rich and powerful Safavid architecture in contract to Safavid architects in early Mughal period. The point that is to be made here is that Safavid architecture generally continued Timurid principles in their buildings, and the third proposition is valid in high phase of Mughal.

CHAPTER 4 : PERSIAN ELEMENTS IN MOSQUE OF PERSIA

4.1. Introduction

The purpose of this chapter is to concentrate on Persian mosques and elements that were inserted ,and developed within this function. This chapter includes three parts; the first overviews Persian mosques in different historical periods (early period after Islam, Seljuk, Illkhanid, Timurid, Safavid), while the second explain the typology of Persian mosque. The main part is about the Persian elements in the mosques of Persia. Definition, origin, significance, morphology, typology, and the history for each element will be separately described. Finally, the Persian geometrical systems that were used in spatial elements will be mentioned.

4.2. History of Persian Mosques

4.2.1. Early Period

After the arrival of Islam in Iran, four basic mosque types have been used (Godard, 1962):

1. Hypostyle mosque (Arabic model)
2. Domed chamber mosque(kiosk mosque)
3. *Ivan* mosque without domes
4. Dome chamber mosque with *ivan*

Hypostyle mosque (Arab model): Such was the perspective power of the "Arab Plan" that its influence permeated mosque architecture in the non-Arab lands as well (Hillenbrand, 1994). Several early mosque have the hypostyle plan with arcades perpendicular to the *qibla*, and with central nave (Tarik-Khana mosque, Damghan, Jami mosque of Fahraj as first Persian mosques)(Frishman & Khan, 2007; Hillenbrand, 1994).

Domed chamber and *Ivan:* Persian mosques acquire its distinctive character by enriching the hypostyle form with two elements deeply rooted in pre-Islamic Persian architecture: the domed chamber and the *Ivan* and a vaulted open hall with a rectangular arched façade (refer to Figure 4.1.). The dome chamber were derived from Sasanian (224-651CE) fire temple architecture called *chahar taq* (Hillenbrand, 1994). *Ivan* is a highly composed complex unit consisting of a barrel vault or modified barrel vault, open to the exterior, either facing onto a court or forming a part of the façade of a building (Golombek et al., 1988).

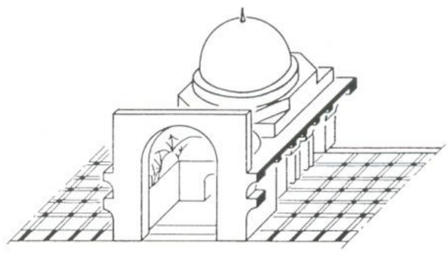


Figure 4.1: Combination of *Ivan* and domed chamber (Frishman & Khan, 2007)

4.2.2. Seljuk Period

The major mosques built or enlarged during this time (such as the Isfahan and Ardistan mosque) have as their focus a monumental domed chamber enclosing the *mihrab*, proceeded by a lofty *ivan* (Hillenbrand, 1994).

The Jami mosque in Isfahan was perhaps the catalyst for the revolutionary development in mosque design and the insertion into the hypostyle plan of four *ivans* facing the courtyard. The idea of the a four *ivans* courtyard is from the antiquated Parthian palaces

(247BC-224AD) (Hillenbrand, 1994). Moreover, by eliminating the columns near the *mihrab* and the insertion dome, the mosque was altered to a mosque with four-*Ivan* and dome (see Figure4.2.). It is perhaps the most distinguished principle model for all major mosques of Persia (Kuban, 1985; pirnia, 2001).

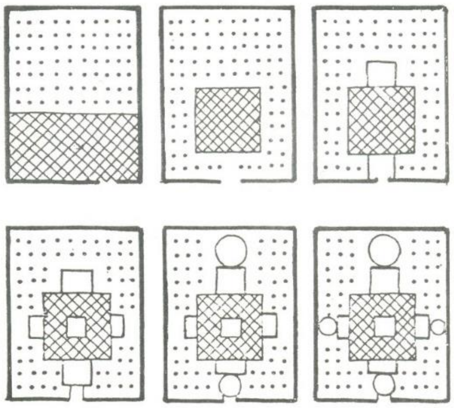


Figure 4.2: The transformation and evolution of hypostyle mosque to four ivan mosque in Seljuk period (Blake, 1999)

4.2.3.Illkhanid Period

With minor variation, the Seljuk tradition (refinement of the four-*ivan* plan) was followed by the mosques of the Illkhanid period (Kuban, 1985), despite several alterations:

- Increase the scale of elements specially *ivans*, dome, minarets.
- Combination mosque with other function such as *madrassa, khanagah,* tomb and shrine(Frishman & Khan, 2007).
- Use continuous double dome (pirnia, 2001).
- *Musalla*: another form of mosques that seems to be common in east of Persia. It is a large open prayer space, sometimes walled, with a *maqsura* in the *qibla* side, this mosques used for great religious feasts (Kuban, 1985).
- The increased use of decorative techniques (Petersen, 2002)

4.2.4. Timurid Period

With the rise of the Timurids in the east of Persia (Central Asia, Khorasan and part of Afghanistan) and its rapid development throughout the whole country, several attributes were applied. Fisherman & Khan (2007, pp. 126,127), Kuban (1985, p. 12) and Pirnia (2001, p. 217) cited the features used in the Timurid mosques that includes:

- Formal incorporation of teaching (religious school) with mosque.
- Attention to symmetry and union on the design.
- False upper galleries linking the *ivans*.
- Multiplicity of paired minarets in entrance *pishtagh* or the *ivans* on the *qibla* side.
- Emphasize display at the expanse of structure(Frishman & Khan, 2007).
- Use discontinuous double dome with high drum.
- Different variation of arch and vaults (pirnia, 2001).
- Dominant use of faience mosaic decoration as decoration both for the interior of mosques and for the portal façades Kuban (1985).

4.2.5. Safavid Period

Through the intrinsic quality of Safavid mosque make, they look as having great artistic value; the period was not marked by any great novelties of plans. The Safavid style replaced earlier tendencies of boldness of conception and vastness of size via the refinement of the finish and intricacy of design (Kuban, 1985).

Numerous Timurid features continued in the Safavid period, such as false upper galleries, Formal incorporation of teaching with mosque, and paired minarets, despite certain characteristics being specific to Safavid mosques, such as the use of novel material of decoration, *cuerda seca* (*haft rangi* tile work), and novel rhythms in courtyard façade (Frishman & Khan, 2007; pirnia, 2001) .

Fisherman& Khan (2007, p. 128) also mentioned that the Safavid period represents the culmination of two important type of Persian mosques: four *ivan* mosque (such as Masjid –I Shah at Isfahan), kiosk mosque (such as Sheikh Lutfullah mosque), both of them in Isfahan .

4.3. Typology of Persian Mosques

Pereira (1994, pp. 100,107), in his book " *sacred Islamic architecture*", classified the Persian mosque into nine types, mentioned below:

4.3.1. Domed Ivan Mosque (Kiosk Mosque)

The pavilion: a dome over a square chamber (the Sasanian fire temple), was adapted to Islamic rituals (Pope, 1965). This layout obviously lent itself to the Muslims by the simple expediency of blocking up the arch nearest to the *qibla*, and replacing it with a *mihrab* (see Figure 4.3.). Examples of this is the mosque of Yazd -i-Khast and Qurva from the Seljuk period, or the Sheykh Lofolah mosque from the Safavid period (Hillenbrand, 1994; Pope, 1965).

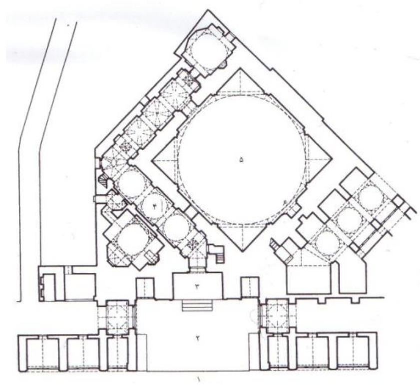


Figure 4.3: Sheykh Lofolah mosque, Safavid period(Stierlin & Stierlin,

4.3.2. Mosque with One or Two Ivans Court

A single *ivan* on the *qibla* side of a courtyard and also mosques with two axial *ivans* occurs in some Seljuk mosques (see Figure4.4.), such as the Firdous mosque and Bashan mosque from Seljuk period (one *ivan* mosque) and Mir Chakhmagh mosque from the Timurid period (two *ivans* mosque) (Pope, 1965).

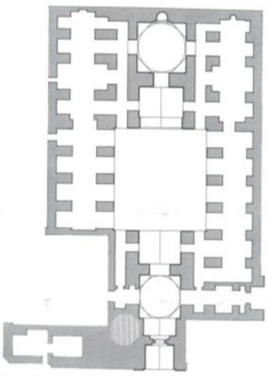


Figure 4.4: Mir Chakhmagh mosque, Timurid period(Golombek, Wilber, & Allen, 1988)

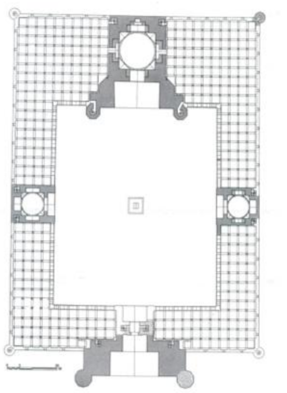


Figure 4.5: Bibi Khanom mosque ,Timurid period(Golombek et al., 1988)

4.3.3. Four –Ivan Congressional Mosque

A harmonious synthesis of traditional elements is present in the *Ivan*, the two or four –*Ivan* court and the *ivan*-dome combination (where the *Ivan* or *Pishtagh* provide access to the domed *mihrab* chamber) (refer to Figure4.5.). As mentioned in 0, the mosque type dominated Persian architecture for several centuries, and it dominated the design of mosques in the eastern Islamic world (Pereira, 1994).

By common consent, the sanctuary *Ivan* was the largest and deepest, the opposite *Ivan* next in size, though often very shallow, while the two lateral *ivans* were usually smaller.

Minarets at the corner of the sanctuary *Ivan* underlined its importance, first encountered during the Seljuk period. (Hillenbrand, 1994; Pereira, 1994).

4.3.4. Ivan Mosque Without Domes

The open Ivan _a simple barrel vault. (Pope, 1965).

Furthermore, Pereira(1994) cited that other types mosques that never quite gained a foothold, such as:

4.3.5. The Square Many-Bayed Omni Domed Mosque

Mosques with roof all covered with many domes

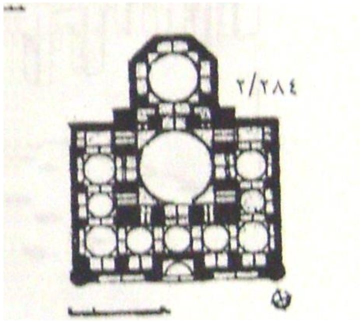
4.3.6. Narthex-and-Noas or Domed Apsidal Mosque

A central dome chamber enveloped on the three sides by a dome veranda (refer to Figure4.6.)

4.3.7. Central Domed Chamber and Omni-domed Wings

4.3.8. Mosque Integrated to Madrassa-Tomb

In later medieval history of Persia (Illkhanid -Timurid - Safavid), the mosque is sometimes hard to disentangle from that of the *madrassa* _tomb _or shrine complex. Prayer and communal worship were, after all, integral to the operation of such "little cities of God", such as the shrine of Ardabil, Natanz, Turbat-i-Jam (see Figure4.7.), and Bastam (Hillenbrand, 1994).



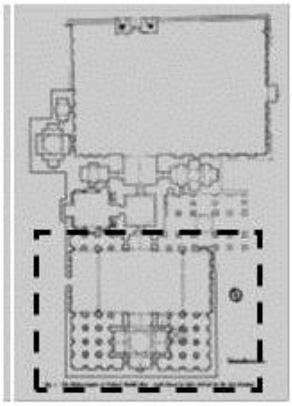


Figure 4.7: Kabod mosque, Timurid period(pirnia, 2001)

Figure 4.6: Torbat Jam tomb, mosque, Timurid period(Golombek et al., 1988)

4.4. Persian Elements in Mosques in Persia

After the arrival of Islam in Persia in 7th century AD, some architectural elements that were purely Persian in origin or invented by Islamic Persian Master builders have been assimilated into the mosques of Persia, being developed in it, and were then transferred to other countries and civilizations. Figure4.8. classified these Persian elements based on three categories (functional, structural, and ornamental) and the collective perspectives of Pereira (1994), Pope(1965) ,Pirnia(2001),Stielin (2002).

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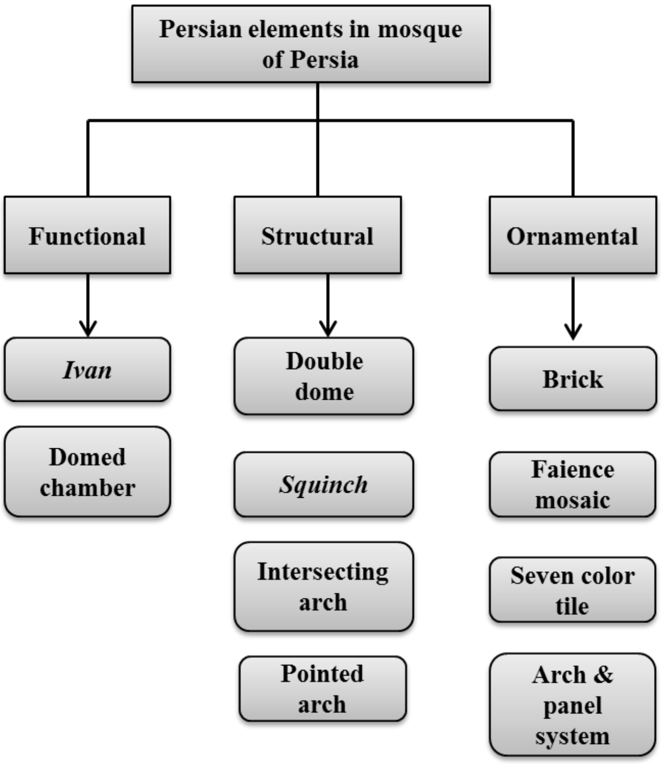


Figure 4.8: Persian architectural elements in mosque of Persia (Author-2011)

4.4.1. Ivan

4.4.1.1. Definition

Golombek & Wilber (1988) defined *Ivan* , entrance portal and *Ivan* screen:

- ***Ivan*****:** is a highly composed complex unit, consisting of a barrel vault or modified barrel vault, open to the exterior, either facing onto a court or forming a part of the façade of a building.
- ***Entrance portal (pishtagh):*** the *Ivan* is used as an entrance passage, often projects beyond the façade of the building, and is usually much larger and more massive than other *ivans.*

- ***Ivan screen:*** the front of the vaulted is framed by a rectangular mass of masonry, which we refer to as the *Ivan* screen. It is composed of the pylons or flanks of the vault built up to its spring line, and continues upward in a horizontal course until it surpasses the crown that creates a false front, which is viewed as structurally unsound (Golombek et al., 1988).

4.4.1.2. Origin

As mentioned in 0, the monumental *ivan* that polarizes the space of the courtyard is distinctively pre-Islamic Persian, derived from the Sasanian (224-651CE) royal hall (Stierlin & Stierlin, 2002).

4.4.1.3. Significance

Ivans serve as indoor–outdoors spaces, affording protection from the sun, and is usually located in open spaces. Defining its axes around the court and placed in the center of a façade, the four *Ivan* emphasizes the axes of the place of worship and the principal *Ivan*, which leads to the hall containing the *mihrab* is large and often framed by a pair of minarets. It indicates the direction of prayer, towards the southwest (Golombek et al., 1988; Stierlin & Stierlin, 2002) .

4.4.1.4. Morphology of Ivan Screen

Blind arches with open arch can articulate the internal façade of *Ivans*. Plinth (lower level) and parapet (in the upper level) defines the horizontal line of the elevation. An inscription frieze that is located above the spandrel and open arch is a place for calligraphy of *suras* from the Koran. A band ties the tree sides together to highlight the vertical lines of *ivans.* A spandrel is the curve triangular form above the main open arch, decorated with floral motifs. The *ivans* may be terminated by semi-domes or barrel vaults. The semi-dome of *ivans* are either ornamented by *squinch*-net or *muqarnas.* The *ivan* may be flanked by minarets, or have minarets ascending behind the screen or above it, which defines and emphasizes the ending line of the *ivans* (refer to Figure4.9.)(Golombek et al., 1988).

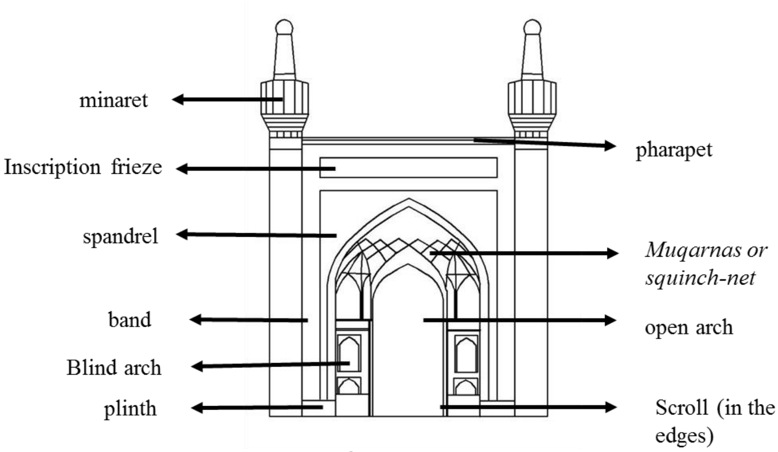


Figure 4.9: Elements of *Ivan* screen (Author-2011)

4.4.1.5. History of Ivan

Seljuk period: One of the key features of the Seljuk period is vast conch-shape *ivans* that face each other and meet at the center of courtyard. These *ivans* is properly made up of a recessed space, which is covered with a pointed or hemispherical vault, but opens to the courtyard *(*Figure4.10.a) (Stierlin & Stierlin, 2002).

Illkhanid period: A distinctive feature of the Jami mosque of Yazd (1324-65AD, the famous Illkhanid mosque) is the tall eastern portal *Ivan* flanked by two soaring minarets (see Figure .d). This portal *ivan*, which is a common architectural prototype of the IlKhanid period, is given a high degree of monumentality by the verticality of the two tall minarets and the vertical orientation of the moldings' lines(Holod, 1972).

Timurid period: The height of the *Ivan* screen reached towering proportion in the Timurid period, serving as a recognizable sign of what lay behind them either in the case of the façade or in the case of that of the *Ivan – muqsura* (the *Ivan* in front of sanctuary of a mosque). The *ivan* itself is never viewed as a passage way .it is used, however, in conjunction with a vestibule, to form the main entrance passage into a courtyard *(*Figure4.10.b&f) (Golombek et al., 1988).

Safavid period: The most important feature of building is the *Pishtaq* of which Andre Godard considered that the transparent, vibrant glazes were among the base extent examples. This *ivan* is especially notable for an ingenious system of interlacing based on two squares overlapping at a 45 degree angle, a formula that is also seen in the Mosque of Imam (1603-18AD) *(*Figure4.10.c&e) (Stierlin & Stierlin, 2002) .

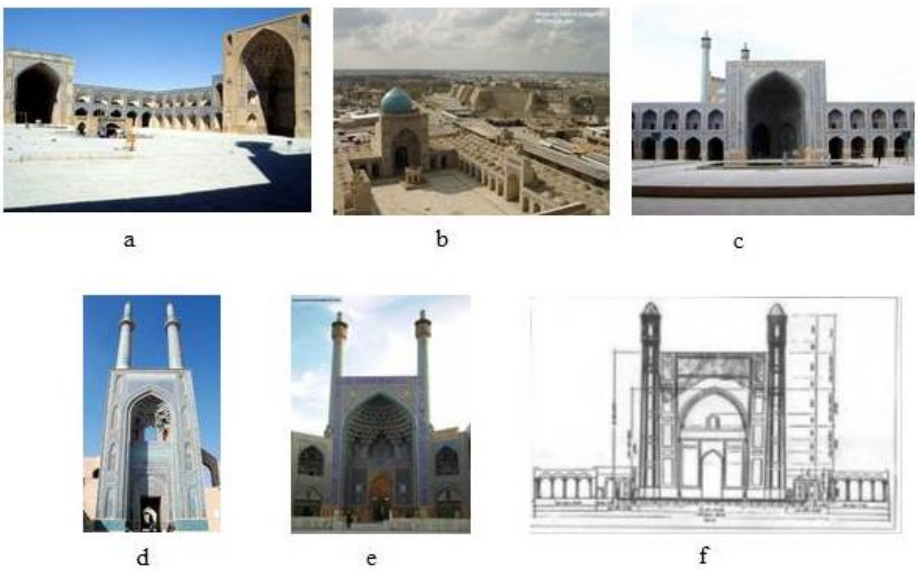


Figure 4.10: Persian *Ivan* and *pishtaq*
a) ***Ivan*** **of Jami Mosque, Isfahan, Seljuk period (Pirnia,1998)**
b)Ivan **of Kalyan Mosque, Bokhara, Timurid period (Pirnia,1998)**
c)Ivan **of Emam Mosque, Isfahan, Safavid period(Author-2011)**
d)Pishtagh **of yazd Mosque, Illkhanid period(Author-2011)**
e)Pishtagh **of Imam Mosque, Isfahan, Safavid period(Author-2011)**
f)Pishtagh **of bibi khanom Mosque, Timurid period (Habib, 2002)**

4.4.2. Domed Chamber

4.4.2.1. Definition & Origin

A dome over a domed chamber (the Sasanian (224-651CE) fire temple or *chahar-Taqis*) was adapted to Islamic rituals (Pope, 1965). This layout obviously lent itself to the Muslims by the simple expediency of blocking up the arch nearest the *qibla* and replacing it with a *mihrab* (Hillenbrand, 1994; Pope, 1965).

4.4.2.2. Significance

Domed chamber with a *mihrab* become a *muqsura* in a mosque, moreover, the dome chamber with the main *Ivan* preceding it occupies the center of the southern side of the court. (Holod, 1972) mentions that this synthesis develops into the standard norm for central part of Persian mosques. The symbolic meanings of the pre-Islamic domes were often significantly traced and developed according to new religious thoughts .such as the cosmic form of the domical structure, figuring paradise, the central focus of the Ka'ba on Earth, and the house of God (heaven). In addition, the dome chamber was also favored due to their ability to cover large spaces without scarifying the unity or the height of the space (Ashkan & Ahmad, 2009; Golombek et al., 1988).

The most prevalent type of dome chamber is the square or polygonal, and later, cruciform plans (refer to Figure4.11.). Cruciform plans are more difficult to accommodate within the confines of a rectangular building. However, it provided the basis for a more fluid concept of an interior space (O'Kane, 1979).

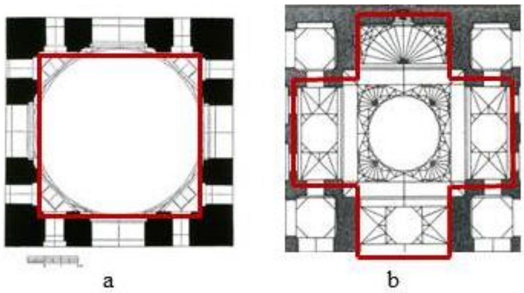


Figure 4.11: Persian domed chamber
a)Square chamber , Jami Mosque, isfahan(pirnia, 2001)
b)Cruciform chamber , Jami Mosque, Torbat Jam(pirnia, 2001)

4.4.2.3.Morphology

Normally, a domed chamber is composed of three main parts: load bearing system, transition system, and the dome (refer to Figure4.12.). The load bearing system is at the lower level, acting as the main body of a domed chamber. It has a composition of positive (blind) and negative (open) arches. Open arches enable relations with other spaces. The setting of the positive and negative shape patterns, which are located surrounding the central plan, chiefly varies in different historical periods with a more open arch; the domed chamber appears more vivid and bright. The upper level of the lead bearing system is a transition system that provide for the transfer of square form of load bearing to the circular form of a dome by using *squinch*, recumbent arch, or *pendative* with revetment of arch-net, *Muqarnas*. The upper level is a dome (mostly internal dome) that covers the whole of the domed chamber. Domed chambers normally have windows in the upper section of load bearing system, or in the transition system(Pirnia, 1990).

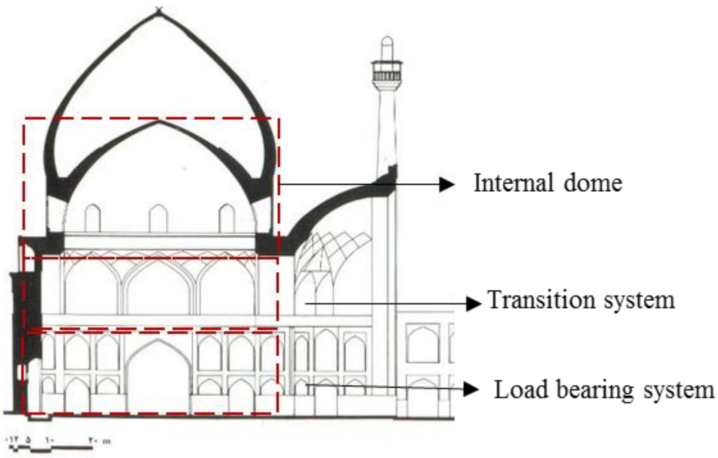


Figure 4.12: Morphology of domed chamber (Author-2011)

4.4.2.4. History of Domed Chamber

Seljuk period: In the early Islamic period, dome chambers may have been used for small neighborhood mosques, such as the domed *maqsura* in the congregational mosque at Isfahan (1086-87AD) (see Figure 4.13.a). Dome chambers on the *qibla* become the norm in Persian congregational mosques. The emphasis on verticality and on lightening the walls of the lower square became typical of Illkhanid dome chambers (Galdieri, 1972).

Illkhanid period: The dome chamber of the congregational mosque in Varamin (1322AD) provides an example of changes in Persian domes in the Illkhanid period. Its taller proportions result primarily from the increased height of the zone of transition, with the addition of a sixteen-sided zone above the main zone of *muqarnas squinches* (O'kane, 1998).

Timurid period : The tradition of dome building has undergone little change, though dome chambers were sometimes surrounded with axial *ivan*s and corner rooms (Golombek et al., 1988). The cruciform dome chamber became the standard form for large covered spaces in Timurid architecture. These structures could be freestanding, or part of a larger ensemble of various functions, mausoleum, mosques, or funerary mosques (See Figure4.13.b). (Golombek et al., 1988) .

Safavid period: One of the best samples of domed champers in this period is Shaikh Lotuf-Allah mosque in Isfahan (1603-18AD). It is the smaller and also the more unusual mosque, and comprises of a single-domed chamber approached via an L-shaped corridor (Petersen, 2002). There were two divergent trends in the interior decoration of domed chambers from the Seljuk period onward. The most prominent was the substitution of plain or painted plaster for bricks, while the other was increasing the use of tile work (see Figure4.13.c)(O'kane, 1998).

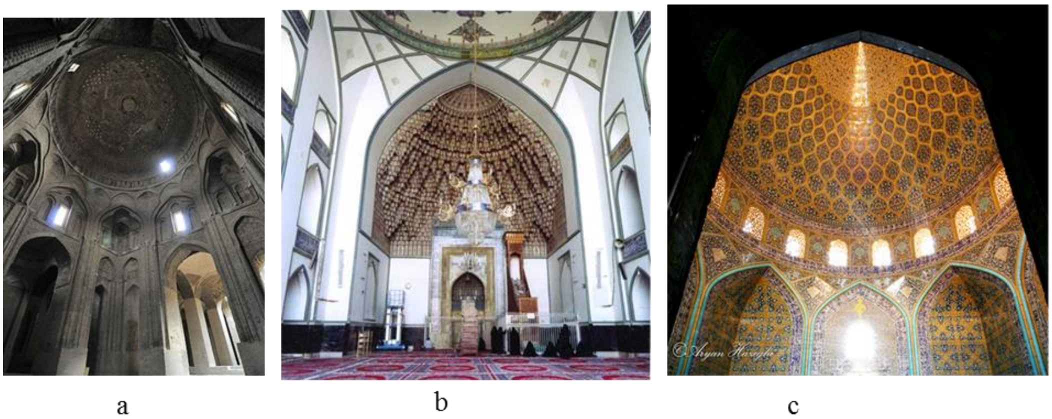


Figure 4.13: Persian domed chamber
a)Domed chamber, Jami Mosque, Seljuk period(pirnia, 2001)
b)Domed chamber , Goharshad Mosque, Timurid period (Razavi, 2005)
c) Domed chamber, Shaikh Lotuf-Allah Mosque, Safavid period(Author-2011)

4.4.3. Double Dome

4.4.3.1. Definition

In the construction of the domes, the shell(s) can be put together in three different ways. These include one, two, and three shells (Hejazi, 1997). However, a few samples of these triple shells that emerged in comparison to large numbers of the other sorts can thus verify its origin from the double-shell domes (Gangler et al., 2004).

4.4.3.2. Significance

One of the main advantages of discontinuous double-shell domes' structure is the separation the weathering surface from the internal shell, thereby substantially improving weather protection (Mainstone, 2001). Architecturally, it permitted an increase in the external size and height of the dome, making it more imposing without the necessary increase in its internal height, which improves its aesthetical meanings and splendors (Hillenbrand, 1994; Michell et al., 1995).

4.4.3.3. Morphology

Morphologically, the commonly identified components of Persian double-shell domes consists of load bearing system, transition tier, drums, and shells that include the external shell (the most visible part of dome), high drum, internal shell, and radial stiffeners within the wooden struts. The latter was used to fill the space between the shells, as well as integrating whole components (refer to Figure4.14.)(Ashkan & Ahmad, 2010).

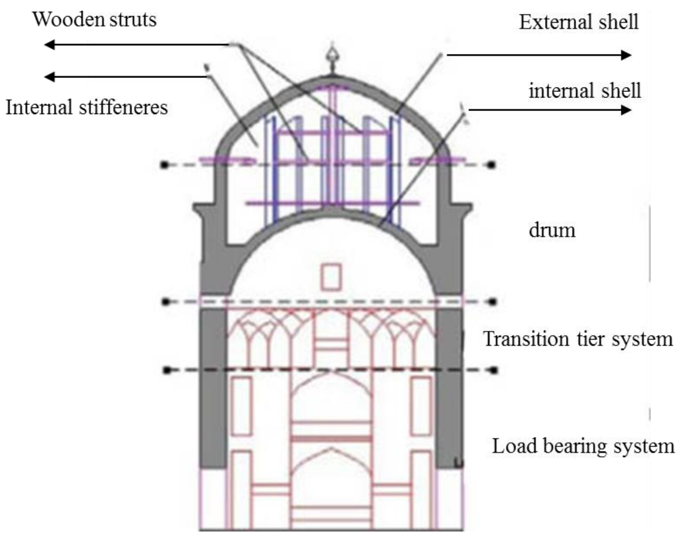


Figure 4.14: Morphology of Persian double dome (Ashkan & Ahmad, 2009)

4.4.3.4. Typology

Regarding the double-shell types, two subdivision groups have been defined based on how these two shells are composed together. They are the continuous and the discontinuous groups (Ashkan & Ahmad, 2010).

- In the continuous double-shell domes, sometimes, there exists no considerable distance between the shells, or they are connected by brick connectors, but very often, the distance between these shells are small (see Figure4.15) (Hejazi, 1997; Stierlin & Stierlin, 2002).

Figure 4.15: Different type of continuous double shell dome(Ashkan & Ahmad, 2009)

- In the discontinuous double-shell domes, there are considerable distances between the two shells. The discontinuity may start either from the base or from the top of the drum (Hejazi, 1997). This is considered to be higher than the other types of the domical typologies.

In order to categorize the derived profiles of the external shells into the identified typologies, in what follows, the three shape-patterns of those typologies are mainly elaborated and schematically designed (Figure4.16.).

- Conical pattern: it is a triangle circumscribed by a rectangle.
- Pointed pattern: it is the feature whose lower arcs (the first and second arcs) are tangent to the two vertical lines that vertical to the end points of the span line.
- Bulbous pattern: it is the prototype where the vertical lines intersected the lower arcs (onio in some textual documents) (Ashkan & Ahmad, 2010).

The conical and pointed types forms the majority of Persian domes in the Islamic periods over the bulbous type. Conceptually, the bulbous domes are considered the last generation of innovative approaches in Persian domes right up till the end of the late Islamic era (Ashkan & Ahmad, 2010).

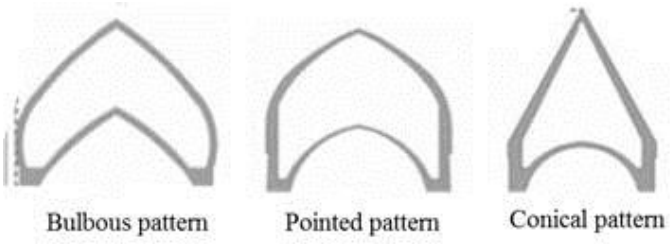


Figure 4.16: Typologies of external shell in discontinuous double- domes (Ashkan & Ahmad, 2009)

4.4.3.5.History of double dome

Seljuk period: The achievements of Seljuk architecture are mainly two methods for resolving conflicts in the design using two shells in such a way that the external shell . That was divorced from the internal shell at a 22.5' angle from their bases of the continuous double-shell dome of such as in Ardestan Jami mosque (10-11th century AD).But this manner is mainly used in Illkhanid period (Ashkan & Ahmad, 2009).

Illkhanid period: The suitable innovation for constructing the colossal state buildings for both sacred and secular purposes is the resemblance of a huge of monumental continuous form and merely discontinuous double-shell domes (with pointed and conical external shells) throughout this realm (Michell et al., 1995).

Timurid period: While the Ilkhanids domes were extensively built for the funerary usages, the Timurids domes were regularly attached to the *madrasa* (religious school), and were often in pairs instead of being on freestanding mausoleums and mosques (Hillenbrand, 1994). The usage of discontinuous double-shell domes became widespread during the Timurid era, with different types of external shell (bulbous and pointed). In the bulbous dome, it began a return below the base of the arch, which results in a slight bulge. This kind of dome was developed toward the middle of the 15^{th} century(Golombek et al., 1988) .

Safavid period: The emphasis on the greatness of buildings, which reached its high level of development in the Timurid era, continued as a principle in the Safavid Empire (Gangler et al., 2004). The most significant accomplishment of this era embraced distinct bulbous domes that are regarded as the last generation of Persian domes. They exerted great influence on architectural styles of Islamic domes, especially in the late Mughal period in India (Stierlin & Stierlin, 2002).

4.4.4. Squinch

4.4.4.1. Definition

Small arch are located at the corner of a building that converts a square space to an octagonal area which may then be covered with a dome (Petersen, 2002). Furthermore, common *squinch* arches, backed by semi domes or groined vaults, form a longstanding tradition in Persia since the 10^{th} century(Golombek et al., 1988).

According to Golombek & Wilber (1988, p. 103), the transition system can be classified into two main group: functional and nonfunctional transition systems (refer to Table 4.1.). *Squinch* is classified as a functional transition system.

Table 4.1 : classification of trasiotion system (Author-2011)

functional transition systems	nonfunctional transition systems
Squinch	*Muqarnas*
Recumbent Arch	Arch-net or *Squinch*-net
Pendentive	

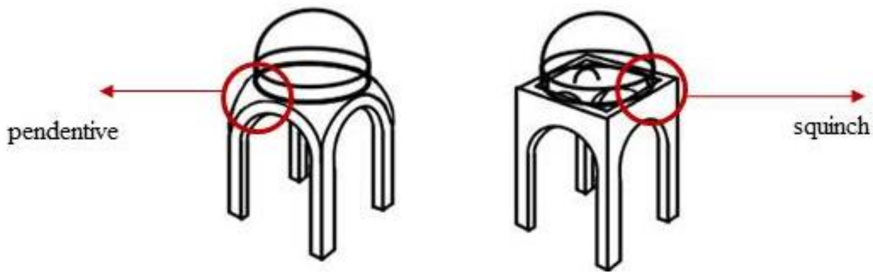


Figure 4.17: Difference between *squinch* and *pendentive* (Author-2011)

4.4.4.2. Origin

The arched *squinch* that is often used in Byzantine architecture originally seems to have been developed, almost simultaneously, by the Roman builders of the late imperial period and the Sasanians (224-651CE) in Persia. Islamic architecture, borrowing from the Sasanian precedent of Persia, makes great use of *squinch* forms (Britannica, 1978).

4.4.4.3. Significance

The transition tier is an essential component of the dome, which made the difference in compositions over historic eras. Architecturally, its main function is to alter its configuration from square to circular by means of the groined arches, which diagonally span the corner of a square plan and form the octagonal lower base of the shell (Ashkan & Ahmad, 2009). The more common arrangement of curved surfaces found in most *squinches* and *pendentives* fulfill exactly the same purpose: it carries the horizontal thrust back to the structure below. The flying buttresses of a Gothic cathedral does the same thing in a more theatrical fashion (Mainstone, 1973).

The distinctions between *squinches* and *pendentives* are not structurally very significant; both serve the same basic purpose. The *squinches* rested on forming a transition from the square space beneath the circular form of the dome, while the *pendentives* fulfill the same function in a different manner. The former, by multiplying and ornamenting the niches or *squinches*, produces the famous stalactite, *pendentive*, while the latter, which come to be common in Europe, developed into a spherical surface (refer to Figure) (Ashkan & Ahmad, 2009; Gye, 1988).

4.4.4.4. Typology

The typology of *squinch* that is based on the view of Golombek & Wilber (1988, pp. 104,105) is described below:

- The simplest form consists of wood or iron beams laid across the corner resting on tangent walls. This method could only be used when the interior of the dome was to be concealed behind plaster revetments, such as the *muqarnas (*Figure4.18.*a).*
- Cellular console *squinch* is a system that places a dome almost directly over the walls in this *squinch* (Figure4.18.b).
- Semi-domes or groined vaults: Arch thrown over the corner is the most common *squinch* system. The placement by the blind arch panels or arch niches in the intervening facets of the octagon (Figure4.18.c).
- Nested or stepped arch (Figure4.18.d).

Figure 4.18: Typologies of Persian *squinch*
a) Wood or iron beams laid across with revetments such as the *muqarnas* , Goharshad Mosque (Razavi, 2005)
b)Cellular console *squinch* , Jahangir Mausoleum (Golombek et al., 1988)
c)Semi-domes or groined vaults, Jami Mosque of Isfahan (pirnia, 2001)
d)nested or stepped arch, , Jami Mosque, Yazd (pirnia, 2001)

4.4.4.5. History of squinch

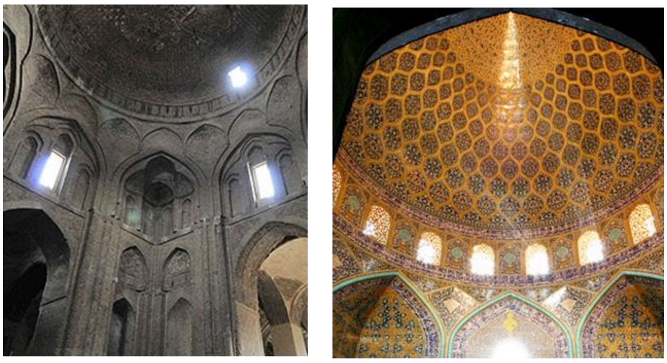
Generally, the type one simplest *squinch* and cellular console *squinch* were mostly famous during the Seljuk period, even though the groined vault could have been developed after the Seljuk period, especially during the Timurid era. The nested *squinch* only became popular during the Illkhanid period(Pirnia, 1990).

Seljuk period: One of the best samples in the Seljuk period, Masjid Jami of Isfahan (1086-87AD) matches the mathematical requirements of the ideal dome. From the floor level, these colonettes lead the eye swiftly up to the typical tri-lobed *squinch*. The *squinch* itself is enclosed by a larger arch that, together with identical arch along the side walls, supports an octagonal ring of sixteen shallow panels merged with the base of the dome (see Figure4.19.a) (Pope, 1965).

Illkhanid period: The Jami mosque of Varamin (1322AD) is another example of a great building of Persian architecture in Illkhanid era. The inner chamber and square on plan is converted into an octagon by *squinches* thrown across the angles. The eight sides of the drum are converted into sixteen by a series of beautifully finished *squinches*, and on the rest of the dome itself (K. Creswell, 1915).

Timurid period: The well-known sample of Timurid architecture in Persia is the Mir-Chaqmaq mosque (1437 A.D), which marks the advances of its huge semi-circular internal shell being placed on the large console mini-arches as the *squinches* tier (refer to 6.3.3 section IV) .

Safavid period: One of the best example of *squinch* in this period is the mosque of Shaykh Lutf Allah(1603-18AD), which was developed into a rich and highly dramatic paneled dome octagon, the abrupt little *squinch* of Parthian (242BCE-224CE) and Sasanian (224-651CE) times. so obtrusively mechanical and has now been disguised and absorbed into each corner arch, in reality, it is a gigantic *squinch*, instead of a small trumpet-like hollow (see Figure4.19.b) (Pope, 1965).



a b

Figure 4.19: Persian *Squinch* a) Isfahan Jami Mosque ,b) Mosque of Shaykh Lutf Allah (pirnia, 2001)

4.4.5. The System of Intersecting Arches

4.4.5.1. Definition

In the transitional system, a curved surface is broken up by a pattern of intersecting arch. It is frequently referred to as a "*squinch* net", but is not genetically related to the *squinch*, and "arch-net" is preferred. The Persian builder‘s term, *rasmi sazi*, were laid out for the "arch-net", but forms part of a larger stellate composition, which is drown (see Figure4.20)(Golombek et al., 1988).

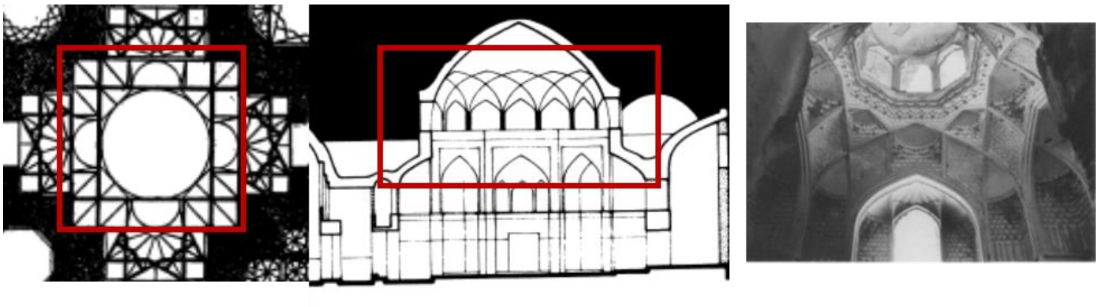


Figure 4.20: Position of intersecting arch , Jami Mosque of Torbat jam, Timurid period(Golombek, 1971)

4.4.5.2. Significant

Intersecting arch provide an alternative and more tectonic system of fractured plans. The preferred plan of the vaulted chamber is square-spanned by four large arches intersecting to form a central cross. The intersecting arches and ribs frame a composite of fractured plans and create an elastic transition to the many-sided star supporting the dome (Pereira, 1994). The space between the lines of intersecting arches often further divided by secondary ribs at right angles to those lines. There are filled with decorative shapes, some of these patterned on structural ones: domes, semi domes, quarter-domes, vaulting radiating from a central axis, rhomboidal facets, tier of rhomboidal faceting, or *squinch* nets and recess panels of angular interlacing strap work or of geometrical patterns, such as those of polygons and stars (Golombek et al., 1988).

4.4.5.3. History of the System of Intersecting Arches

Timurid period: The Timurids, whose monuments mark the climax of Persian achievement, brought the system of intersecting arches to fruition. The double dome is a particularly significant contribution of this era (Pereira, 1994). Timurid architects revived and elaborated the unusual Seljuk stellate-form vaults on the system of intersecting arches as a substitute for the *squinch* system, and the arches could cross to form the sides of polygonal figure the intersections resulted in triangles that could be combined in shapes reminiscent of kites, shields, and stars (Golombek et al., 1988).

Safavid period: architects in this period were bolder than Timurid in designing the intersecting arch , the mannerist fashion they moved the arms on the cross and made them coincide with the diagonals of the square , the smaller square at the center then appeared to be poised on the angle rather than reposing on a side –so creating in dome(Pereira, 1994).

4.4.6. Pointed arch

4.4.6.1. Definition

Arches and vaults with very distinctive profile is characteristic of Persian buildings. It is neither semi-circular arch nor a simple pointed arch (like a gothic arch), although it is derived from both, and has two, three, or four centers (see Figure4.21.) (Stierlin & Stierlin, 2002).

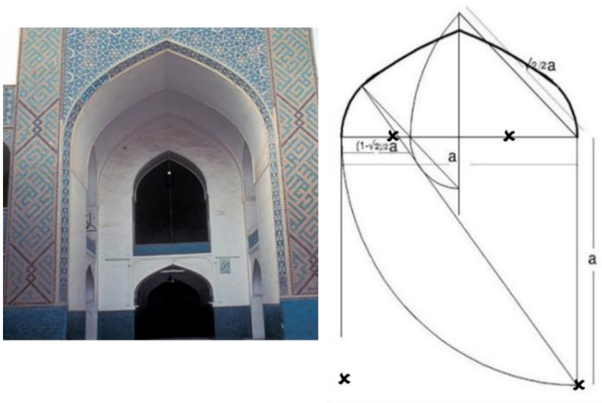


Figure 4.21: Persian pointed arch (Author-2011)

4.4.6.2. Significance

The advantage of this type of profile over a semi-circular arch is that it exerts less outward trust for equal span, and also where a sharply curving shoulder is blended with gently curving upper section. Walls also started to become thinner (Pereira, 1994; Stierlin & Stierlin, 2002). The disadvantage are that the components elements are not identical, and that the shallow angle of the inner longer, arches makes the use of centering a necessity (Stierlin & Stierlin, 2002).

4.4.6.3. Typology

The type of arches includes most of those formed in the surviving monuments; the general division is based on the number of centers that includes Two-Centered, Three-Centered, Four-Centered, Segmental, and Broken Headed(Golombek et al., 1988). The most group of Persian pointed arch is Three-Centered and Four-Centered that comprises of eight categories based on the view of Pirnia (1991, pp. 15-42)(refer to Figure4.22), all categories of Persian pointed arch can be classified into two themes: load bearing arch, non-load bearing arch (for ornamentation). The characteristic of each Persian pointed arch can be listed in the following order:

- Category one (or *chamaneh* arch – in Persian): this arch belongs to load bearing arch and it comprises of the intersection of two ellipses, and has two centers.
- Category two (it was named *kalil* arch in Persian): this non-load bearing arch, it has two types (2-1, 2-2); the former has one center, while the latter has three centers, with more usage than type 2-2 in Persian Islamic architecture.

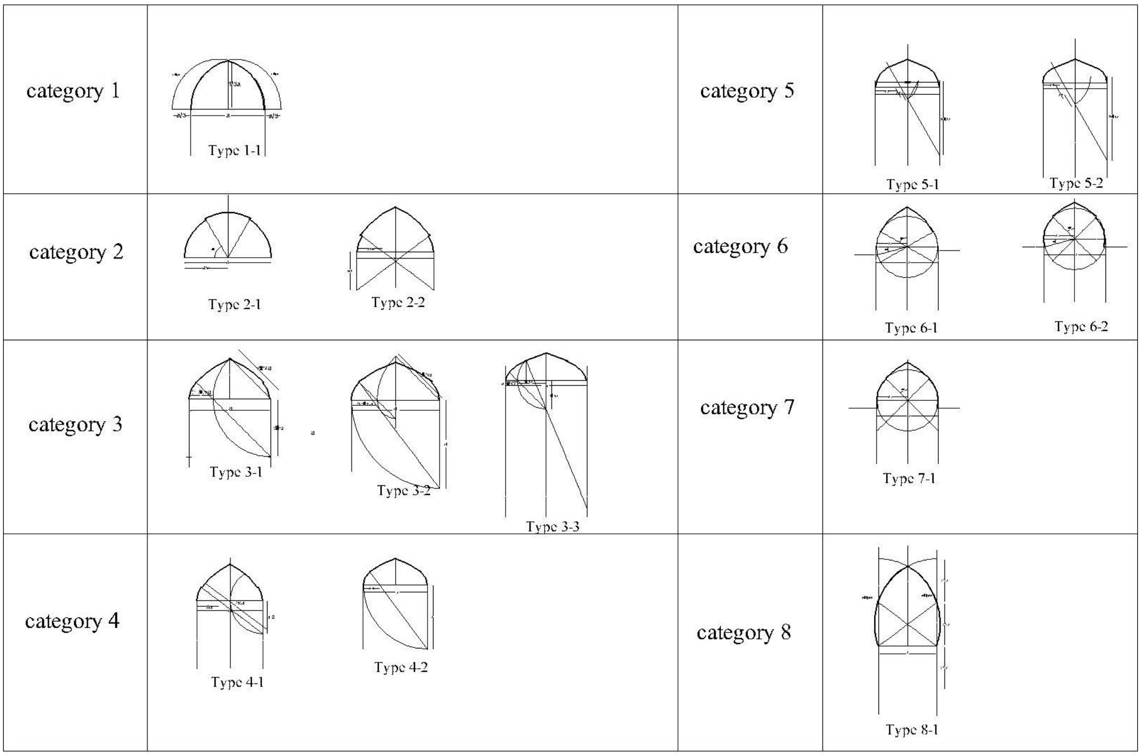


Figure 4.22: Categories of Persian pointed arch(Pirnia, 1991)

- Category three (or *Pang-O- Haft* arch in Persian manuscripts). Similar to category one, it is regarded as load bearing arch with four centers. *Pang-O- Haft* arch has three types (type 3-1(sharp), 3-2(medium), 3-3(shallow)). These vary based on the variety of rise. Type 3-1, or the sharp type, is suitable for covering big and high spaces. Type 3-2 or medium type was used for covering small and medium spaces.
- Category four or *seh-bakhshi:* it was*, like Pang-O- Haft* arch, regarded as popular Persian arches with four centers, however, it is incapable of bearing high pressure, and are more utilized for small spaces such as corridors. This arch also has two types (4-1(sharp), 4-2(shallow)).

- Category five or *shakh bozi:* it can be classified as famous and high usage non-load bearing arches, and be drowning with four centers. Similar to the previous category, it was divided into two sharp (5-1) and shallow (5-2) types.
- Category six or *shabdari:* this load bearing pointed arch was applied for covering external shell of domes. This arch is drawn in the form of a circle, and it has four centers. *Shabdari* arch varied in sharp (6-1) and shallow (6-2) types.
- Category seven or *patopa:* this arch is similar to *shabdari* arch used for domes, with some changes.
- Category eight or *sarvak*: *sarvak* arch is utilized for covering high domes, as it comprises of intersecting two vertical ellipses and this arch having four centers.

4.4.6.4. History of Pointed Arch

Among load bearing arches, the Category one (*chamaneh*) arch was more popular in Seljuk and especially Illkhanid periods. A Category two (*kalil*) arch was used mostly in Illkhanid and Timurid eras, moreover, Category three (or *Pang-O- Haft*) became famous and widespread in Timurid period, and also after Timurid, remains the most popular Persian pointed arches. The groups of arches that were used in the domes mostly applied in Timurid and then Safavid are Category six (*shabdari*), Category seven (*patopa*), and Category eight (*sarvok*). The last group and the non-load bearing arches can be found from the Seljuk and then other historical periods, for instance, Category four (*seh-bakhshi)* and Category five (*shakh bozi*)*(Pirnia, 1991, 2001).*

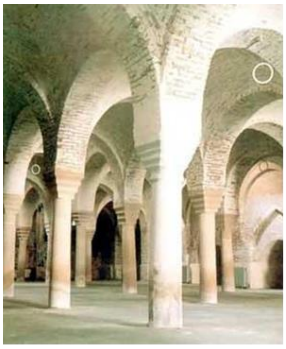
4.4.7. Brick

The use of brick in Persia was in any case a natural outcome of the geology of the country and the great frequency of earthquakes (Stierlin & Stierlin, 2002).

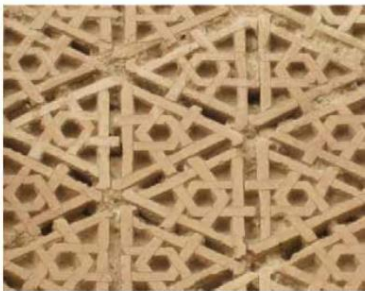
4.4.7.1.History of Brick

In the Seljuk period, two techniques of brickwork decoration (*hazarbaf*) were used, one employing bricks of standard size arranged in simple patterns, while the other using bricks specially cut or manufactured for the purpose (see Figure4.23.a). The latter technique was more suitable for inscriptions and complex motifs (refer to Figure 4.23.b). Also, during Seljuk period, buildings began to be decorated with glazed bricks and colored ceramic tile inlays (Petersen, 2002). One of the best example brick work in this period is in the dome of Isfahan Jami Mosque (1086-87AD), which is the quality of the brickwork that is the best surviving example of Seljuk bricks (Petersen, 2002).

During the Seljuk and Ilkhanid periods, the preferred colors were turquoise, light blue, and dark blue. In earlier buildings, glazed tiles and bricks were set into the exterior walls of buildings to enliven the uniform earth colors of the brick, and during the Seljuk and Illkhanid periods, standard bricks and cut-and-molded bricks were used in a number of brick-bonding patterns. These were revetment on the fabric, and the patterns included common bond, double common bond, Diagonal Square, chevron patterns, and heritage patterns. By the Timurid period, the bonding patterns executed in unglazed brick has gone out of fashion (Golombek et al., 1988).



a



b

Figure 4.23: Brick in Persian mosque
a)First type in Isfahan Jami Mosque, Seljuk period(pirnia, 2001)
b)Second type in Farimod Mosques, Seljuk period(pirnia, 2001)

4.4.8. Faience Mosaic

4.4.8.1.Definition

Faience Mosaic has been described as a patterned arrangement of closely fitted small pieces of tile, which have surface glazes of different colors. Usually, panels of mosaic faience display floral forms, as this technique lends itself to curvilinear design. There are, however, panels where the small pieces establish geometric patterns (Golombek et al., 1988).

4.4.8.2.History of Faience Mosaic

This Persian elements was widespread, firstly during the Illkhanid period (pirnia, 2001).

Illkhanid period: Wide use of Masonic and relieves, especially in interiors, begun in the Illkahnid period, but it was developed heavily during the Timurid era (Pope, 1965).

Timurid period: The technique of mosaic faience soon became widespread: whereby large areas would be covered by tiles especially cut or shaped to form geometric and floral designs, entire *ivans* and *pishtaqs* were covered with floral motifs. The use of polychrome ceramic becomes widespread, leading to the emergence of new bold forms. In Timurid monument mosaic faience, it was displayed in a masterly fashion. Although the palette included several colors such as dark blue, light blue, and white set the prevailing color harmony, Timurids architects introduced new colors including green and yellow (see Figure4.24.b)(Petersen, 2002; Stierlin & Stierlin, 2002; Wilber, 1987) .

Safavid period: : Using the last type of ornament mosaic faience occurred during the Safavid era, even though in this period, architects preferred to use *haft_rangi* tiles instead of the mosaic faience (see Figure4.24.a)(pirnia, 2001).

a b

Figure 4.24: Faience Mosaic in Persian mosque
a)Shah mosque , safavid period (archNet)
b)Bibi khanom mosque , Timurid period(archNet)

4.4.9. Seven Colour (Haft Rangi, Cureda Seca)

4.4.9.1. Definition

Covering the surface with a glistening robe of ethereal hues, not with so much of mosaic faience as of painted tile in “seven color”(Pereira, 1994). Soviet scholars refer to this technique as majolica, while others use the term *Cuerda Seca*. However, it seems appropriate to employ the Persian term *haft rangi*, or “seven color”(Golombek et al., 1988).

Comparison between seven-color and faience mosaic: Seven color tiles could be produced in patterns and colors. This closely resembles mosaic faience, where each faience mosaic tile piece was cut into a different shape to fit its designated place, but the *haft-rangi* is usually a square tile that incorporates various colors in one firing (refer to Figure4.25)(Thomasen & Searls, 1988).

Figure 4.25: Seven color tile. Shah mosque, Safavid period (Author-2011)

The advantage of this technique is that it is possible to cover large areas fairly cheaply, aesthetically less complex than mosaic tile technique, economical, and fast, was juxtaposed to the mosaic tile technique. It glitters in the sun to a magnificent effect, a process that enabled them to apply more colors to each tile, creating richer patterns, and is easier on the eye. Although ill-suited to dark spaces, such as the sanctuary and the quality of the colors was inferior to that produced in tile mosaics (Blake, 1999; Blunt & Swaan, 1966; Golombek et al., 1988; Petersen, 2002; Stierlin & Stierlin, 2002).

4.4.9.2. History of 'Haft Rangi' (Seven Colours)

This Persian elements was firstly used during the Timurid period (pirnia, 2001).

Timurid period: One of two methods used for the exterior decoration in Timurid architecture is under glaze-painted tiles, known as '*haft rangi'* (seven colors) that these tiles display from two colors, to as many seven color. The under glaze-painted tiles tended to be of a lower quality, but were useful for covering large areas. However, this method becomes widespread during the Safavid period (Petersen, 2002).

Safavid period: This method becomes widespread during the Safavid period, for example in the Mosque of Imam, by exploiting the *haftrangi* (seven colors) technique, the architect could draw attention to particular zones of their design, the whole domed chamber and other inside and outside spaces covered by it (Petersen, 2002; Stierlin & Stierlin, 2002).

4.4.10. Arch and Panel System

4.4.10.1. Definition

The arch and panel system is architectonic and decorative forms by one consistent system of articulation, and the relationship between arch-and-panel and arch-and-arch. This system is based on structural forms, and thus has a potential architectural character, which a mode of flat decoration like luster tiling is incapable of entirely suppressing (Pereira, 1994)

4.4.10.2. Topology of Arch and Panel System

Arch and panel systems systematically alternate with panel and arch, vertically and horizontally.

- Empanelling: arch is contained within a panel
- Multiplication: when there is progressive increase upwards framed by arch
- Intersection: arch cross arch
- Enflaming: arch is framed by arch
- By repetition of the same or similar arcade patterns, the systems serves to unify the surfaces and voids of the structure, as well as to control the decoration covering its walls (Habib, 2002).

4.5. Persian Islamic Geometrical System (for Functional Elements)

One of the key points of spatial elements is how the proportions and ratios of these elements were formed. Islamic Persian master builder followed specific geometrical systems during different historical periods. Golombek (1988) mentioned that the geometrical basis of design in Persian architecture was not comparable to western notions of proportion, which are more concerned with the repetition of similar or related forms. The Islamic Persian system, aside from its practical values as a working method, ensured harmony in parts, whereby all of the parts were related to a single entity, as the parts of the square, triangle, and pentagon are all related to each other (Golombek et al., 1988). Figure 4.26. shows the geometric systems that had been used in Islamic Persian architecture since the 10th century. There were:

1. The *square* (system 1) and its derivations, most important of which were the diagonal (√2), it's half and it's double.
2. The *equilateral triangle* (systems 2-3) and its derivation, the side and the height (√3/2), sometimes, the geometry of the square and the equilateral triangle were combined, as in the rectangles of (√2 /√3) (pattern3). The sides of equilateral triangle are used for the niches in domed chambers, with intersecting arches as its support system.
3. The *semi square* (systems4-5-6-7), usually formed by dividing the square of a room into halls by drawing the diagonals of two sets of semi squares, with one arriving at a small square in the center, whose side is 1/√5 (system 4). The diagonal itself (√5/2) plays an important role, particularly in determining the elevations (system 7); these proportions are used to design a façade.
4. The *root five rectangle* (system 8-9-10): Using the semi-square, the base could be divided in another way, known to the Greeks as the "mean-extreme" ratio, which plays

a part in the construction of the “Golden section”. This is done by marking off on an arc, the length of the height, and along the hypotenuse, as in the previous case, but then drawing on the second arch, with its center at the smaller angle, through the point in the hypotenuse. Where this arc cuts the base of triangle, its divides a line into two segments [(√5 -1)/2] and [(3-√5)/2]. Multiple of both segments were commonly used in designing interior and exterior facades, as well as many other capacities.

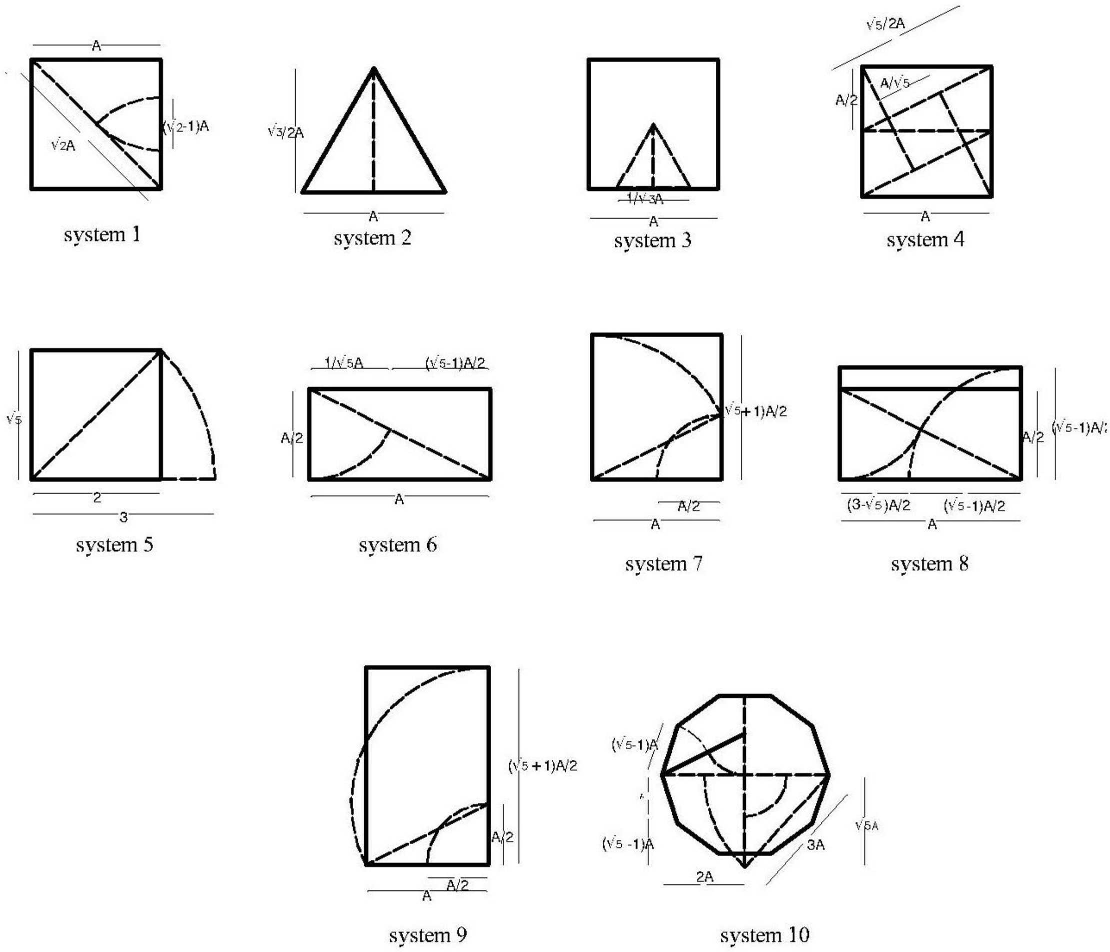


Figure 4.26: Different proportional systems in Persian architecture (Golombek et al., 1988)

4.6. Summary

4.6.1. Popular Typologies in Persian Mosque Architecture

Among variable types of mosque that developed in the history of Islamic Persia, these models had the determinative situation:

- **Four-Ivan mosque** As a Persian model, firstly being applied during the Seljuk period, with the conversion of the hypostyle plan to four *ivans* with a courtyard. In the latter period, domed chambers were added in the back of other *Ivans*. The culmination of this mosque type occurred during the times of Timurid and Safavid. Safavid mosques were the most advanced four-*Ivan* mosques. In addition, this model have also been continued as typical form, especially for congregational mosques, and also became, in time, the dominant mosque type of the eastern Islamic world (Pereira, 1994).
- **Mosque with one or two *Ivans*, court** had specific position, because this model was similar to the typical model (Four-Ivan mosques), particularly in the east of Persia between the Seljuk and Timurid dynasties.
- Another mosque-type**- kiosk mosque-** introduced during the early periods, failed to prevail due to its small-scale and existed only during the Timurid period, mostly applied due to the variety of mosques in this era.

4.6.2. Evolution of Persian elements in mosques

Table 4.2. shows that the process of inserting, using, development, and culmination of Persian elements in mosques of Persia are based on the main historical periods. Two main points must be taken into account: the origin and culmination of each Persian architectural element.

The origin of some elements belongs to pre-Islamic Persia, such as *ivan*, domed chamber, *squinch*, and bricks, while others belongs to the Islamic period of Persia, for example, double dome (Illkhanid), mosaic faience (Illkhanid), intersecting arch, and seven-color tile (Timurid). Pointed arch, "arch and panel system", and brick were used in different faces in all Islamic Persian periods.

The culmination and apex of most of Persian elements belongs to Seljuk (*Ivan*, domed chamber, *squinch*, brick) or Timurid (double dome, intersecting arch, mosaic faience, pointed arch) eras, with only the seven-color tile being developed in the Safavid period.

Table 4.2: The process of development of Persian elements based on historical periods (Author-2011)

Persian elements	Seljuk	illkhanid	Timurid	Safavid
Ivan	▲			
Domed chamber	▲			
Double Dome			▲	
Squinch	▲			
intersecting arches			▲	
The Pointed arch			▲	
brick	▲			
seven color				▲
faience mosaic			▲	
Arch and panel system				

Culmination period ▲

- ***Ivan* and domed chamber, squinch:** Were when the most innovations and changes that have been created in the Seljuk period, with the important point was the insertion Persian elements, such as *Ivan*, domed chamber, and *squicnh* in the mosque and replacement in the Persian four Ivan mosque with the Arabic model (hypostyle mosque). These elements have existed in Persia since before Islam, although they were later integrated into mosques during the Seljuk period.

- **Double dome, intersecting arch, pointed arch:** Some other elements, such as double dome, intersecting arch, and pointed arch were developed and culminated during the Timurid period. In earlier periods (Illkhanid), most of the mosque utilized continuous double dome, but the discontinuous double domes have become the most wide spread type in the Timurid period, due to the concentration to increase the height of façade.
- **Material (brick, faience mosaic, Seven colour tile):** In the early Islamic period and the Seljuk era, different types of bricks were used in Persian mosques with the main change in its material. It was continued its development in the Timurid period using faience mosaic; for faster and easier work, it was replaced by the seven colour tile during the Safavid era.

Moreover, Table 4.3 presents the fact that the level of study for each Persian elements are based on architectural historians, and it shows that the most concentration is in *ivan*, domed chamber, double dome, *squinch*, and pointed arch due to the impotence and vastness of this elements. The Persian material can be regarded as one feature of each element. The final list of Persian elements that can be studied in case studies in the next chapters are *Ivan*, domed chamber, double dome, *squinch*, pointed arch (see Figure4.27).

Table 4.3: Study Persian elements in the mosques based on famous architectural historians (Author-2011)

		(Pope, 1965)	(Hillenbrand, 1976)	(Galdieri, 1972)	(Habib, 2002)	(Gye, 1988)	(Golombek et al., 1988)	(Hillenbrand, 1994)	(Pereira, 1994)	(pirnia, 2001)	(Habib, 2002)	(Petersen, 2002)	(Stierlin, 2002)	(Anisi, 2006)
1	*The Pointed arch*	✓					✓		✓	✓			✓	
2	*Ivan*	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
3	*Domed chamber*	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	
4	*Double Dome*	✓			✓		✓	✓	✓	✓	✓		✓	
5	*Squinch*	✓				✓	✓		✓	✓	✓	✓		✓
6	*intersecting arches*	✓					✓		✓		✓	✓		
7	*brick*	✓					✓		✓	✓		✓	✓	
8	*seven color*	✓					✓		✓	✓		✓	✓	
9	*faience mosaic*	✓			✓		✓		✓	✓		✓	✓	
10	*Arch and panel system*								✓		✓			

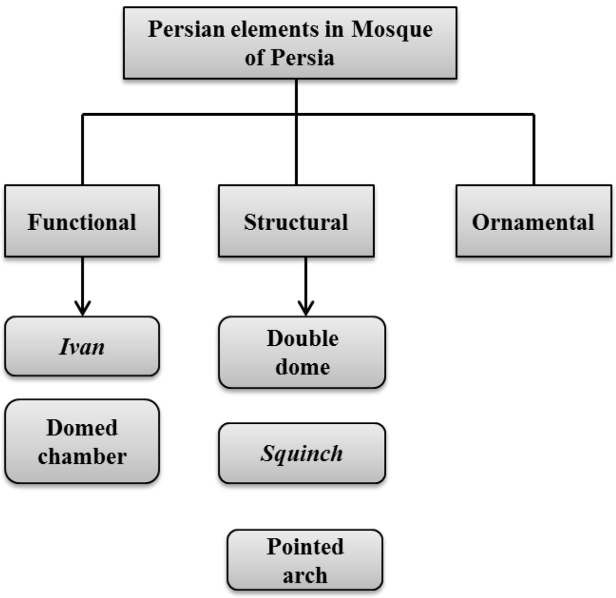


Figure 4.27: Revised Persian architectural elements in mosque of

Consequently, the functional Persian elements (domed chamber and Ivan) can be studied in two manner: morphologically and geometrically (it means how, and which Persian geometrical systems were influenced in these elements), and other type of elements (structural and ornamental) elements that can be considered in a typological manner.

CHAPTER 5: RESEARCH METHODOLOGY

5.1. Introduction

The aim of this chapter is to provide a critical discussion on the approach selected for developing the research activities to achieve the research objectives. This chapter comprises of twelve sections. The first section defines the research process. The next sections discusses the research design and research paradigm and it continues with research methodology. The fifth part describes the research approach used in this research. Focusing on the methods of collecting data is the next step, where a thorough description of the instruments and procedures are given. The description of techniques for data analysis and study trip follow in the next sections. The final sections are concluded via results, discussion, and validity of research.

5.2. Research Process

The process of defining the research questions is the most important step during a research, which requires a full understanding to provide significant clues regarding the proper strategies being used. A critical analysis of the literature framework was done in the second phase, comprising of three sections. After choosing the best methodology in phase three (case study), the work continues with data collection, analysis, and evaluation in phase four, drawing from the previous analysis of each case studies and comparative analysis in the three phases. However, work on the literature review was continued and updated up until the end of the research. The analysis of the findings led to the formation of the conclusions and recommendations, which was the last section of the research

(Kumar, 2010). Figure5.1. illustrates the generalized research process to attain the purpose and objectives of this research. The activities undertaken is shown in the flowchart and it explained in more detail, within the related part of the research.

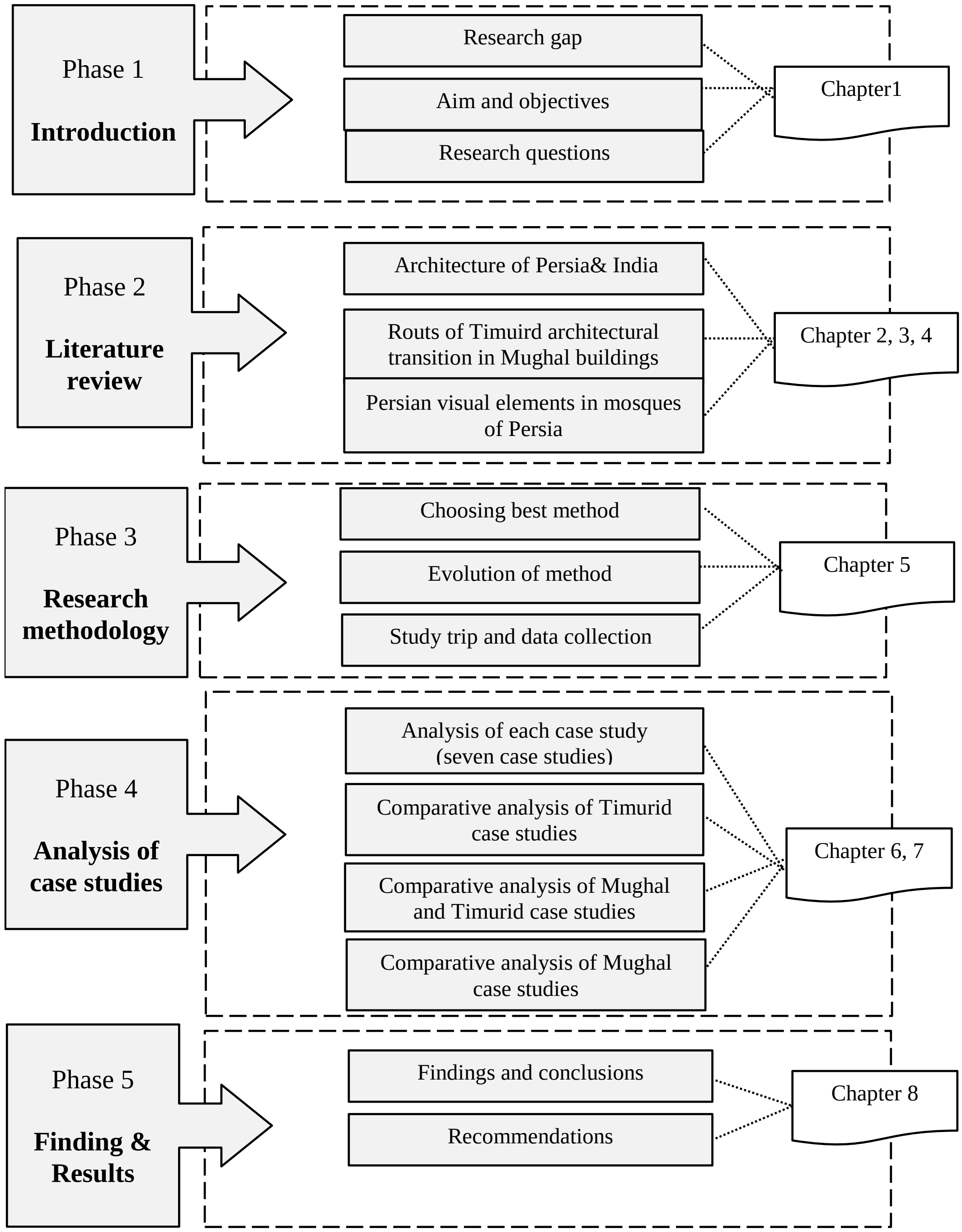


Figure 5.1: Operational framework and flowchart (Author-2012)

5.3. Research Design

A research design is a plan, structure, and strategy of investigation that is conceived to address research questions or problems. The plan forms the complete scheme or program of the research. It includes what the investigator will do from forming research question, and their operational implication to the final analysis of data. Figure5.2 represents the research design frame work, with the first level being the interpretivism as a research paradigm, continuing with research methodology, indicating that the best one for this research is historical interpretive. Among the research approaches, case study was chosen for this research. Observation, architectural documents, and audiovisual aids are the three source evidence, with the research analysis formed by comparing between case studies in different phases.

Besides that , Table 5.1. shows research framework that each research question with related research objective and related approach of analysis(method, instrument, analytical technique & analytical results) were described.

Table 5.1: Research framework (Author-2012)

	RESEARCH QUESTIONS	RESEARCH OBJECTIVES	Approach of analysis			
			Method	**Instrument**	**Analytical technique**	**Analytical results**
1	How Timurid architectural elements transferred and influenced in Mughal buildings (1526-1707AD) in Indian subcontinent?	To define and verify the routes of Timurid architectural influence in Mughal buildings of Indian subcontinent with regard that Timurid (1370-1525AD) and Mughal (1526-1707AD) periods were not concurrent.	Literature review	Secondary data	Desk study	The different propositions of channels and ways of Timurid architectural influence in Mughal mosques
2	What are the architectural elements that were originally Persian, in the mosques of Timurid period (1370-1525AD) in Iran?	To identify the architectural elements which were originally Persian, in the mosque of Timurid period (1370-1525AD) in Iran.	Historical interpretive	Case study	○ direct observation architectural documents ○ Audiovisual material (photography)	Timurid architectural elements with Persian origin in Timurid mosques
3	What are Timurid architectural elements that transferred and influenced in Mughal mosques of India (1526-1707AD) with emphasize on Persian geometrical analysis for specific spatial elements	To examine selected Mughal mosques of India (1526-1707AD) that have been influenced by Timurid architectural elements, with emphasize on Persian geometrical analysis for specific spatial elements	Historical interpretive	Case study	○ direct observation architectural documents ○ Audiovisual material (photography)	Timurid architectural elements in Mughal mosques based on the propositions of Timurid influence
4	How and why Timurid architectural elements that influenced in Mughal mosques of India, modified and evolved and developed base on two periodical Mughal phases (early and high)?	To define the evolution and alteration of Timurid architectural elements that influence Mughal mosques of India based on two periodical Mughal phases (early and high) and contributing factors	Historical interpretive	Case study	○ direct observation architectural documents ○ Audiovisual material (photography)	Evolution and alteration of Timurid architectural influence in Mughal mosques

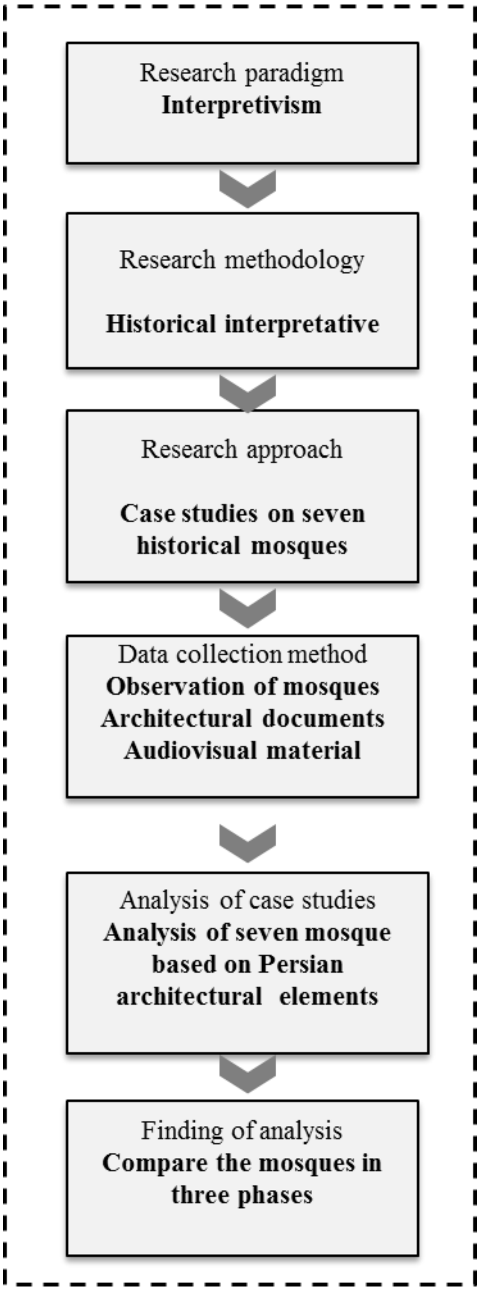


Figure 5.2: Research design framework (Author-2012)

5.4. Interpretivism: as Research Paradigm

Research paradigm is used for three main sources; to help establish appropriate facts, to match facts and theory, and to help articulate the theory. Bogdan & Biklin (2007) defined a paradigm as a loose collection of logically related assumption, concepts, or propositions that orient thinking and research, or the philosophical intent or motivation for the study being undertaken.

There are five common paradigms that can be adopted by researches in the field of architecture, proposed by Graot & Wang (2013), namely positivist , post-positivist , critical theory , constructivism, and participatory. Although there are also other theoretical research paradigms that influences the way of knowledge is studied and interpreted, there are also interpretivism, structural, pragmatic, and transformative paradigms (Mertens, 2005).

Since the current study involves the investigation of one architectural period (Timurid period) being transferred and influencing another (Mughal ear), the research's main focus is the interpretation of historical events. Therefore, the identification and collection of evidences concerning historical events are required. In this case, interpretative is the paradigm best suited for this task (see Figure)

5.5. Historical Interpretative: as Research Methodology

Graot & Wang (2002, p. 180) addressed three approaches to qualitative research in architecture: grounded, ethnography, interpretive. They also pointed out that the special approach for historical research is called the interpretive–historical approach. Interpretative approach is model that provides a process to derive meaning from data that goes beyond analytical emphasis (Hatch, 2002). *Historical* inquiry is very similar to qualitative impossible concerning a complex social phenomenon, and seeks to collect as much evidence as possible from the phenomenon. This requires searching for evidence, collecting, and organizing that evidence, evaluating it, and constructing a narrative from the evidence that is holistic and believable. Throughout the process, interpretation is the key factor (refer to Figure5.3).

Moreover, Groa t& Wang (2002, pp. 137,145) gathered a four-way historical interpretation comprising : casual explanation of history , history as the movement of absolute spirit , structuralism , and poststructuralist (refer to Table 5.2). Among these categories, the second factor is more suitable for this research. This was derived from the thought of the philosopher G.W.F Hegel, who holds that history is an ongoing evolution of communal consciousness or mind. Based on Hegel view, “the movement of spirit“ is one of the few interpretative approaches that could explain transitions from one style to another(L. N. Groat & D. Wang, 2013).

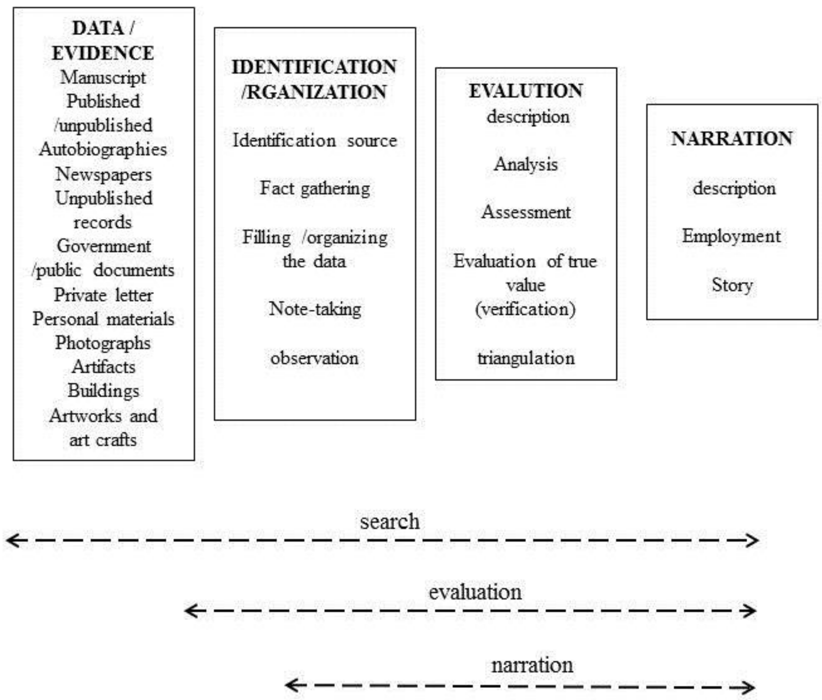


Figure 5.3: Chart of interpretative research (Groat&Wang, 2013)

Table 5.2: The various ways of historical interpretation (Groat&Wang, 2013)

Ways of historical interpretation	Description
casual explanation of history	By using "Covering low" which posit no essential difference between behavior of natural phenomena and the behavior of social phenomena.
history as the movement of absolute spirit	History is ongoing evolution of communal consciousness or mind.
structuralism	This system have its own organic properties, it means Structural system means self -contained, self-regulating, self-transformative.
post structuralism	The idea of an orderly self-defining, self-regulating and self- transforming system is questioned. Post structuralism understands discourse as something like cultural manifestation of the trafficking of thought.

5.6. Case Study: as Research Approach

Yin (2009a, p. 18) define a case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. In addition, the case study research approach enables the researchers to elaborate and explain in detail all the theoretical issues pertinent to the phenomenon of the study in order to produce holistic and meaningful results. Moreover, case study, as a qualitative method, enables the researcher to "get under the skin" of a particular group or organization in order to discover what actually occurred (Gillham, 2000).

Even though the case study is preferred in the examination of contemporary events, the relevant behaviors cannot be manipulated. The case study relied on many similar techniques in history. Since the research seeks to investigate the transition of Timurid architectural elements in Mughal mosques of the Indian subcontinent, the case study model is chosen as the main approach. Moreover, the case study's unique strength is its ability to deal with a fully variety of evidences-documents, artifacts, interviews and observation – beyond what might be available in a conventional historical study (Yin, 2009a) .

The result from the case study can be generalized, not through statistical generalization, but through analytical or theoretical generalization, meaning that the findings from one study can be used as a guide to what might occur in another (Kvale & Brinkmann, 2008). In social science, the strategic choice of a case may greatly add to the generalizability of the case study. When the objective is to achieve the greatest possible amount of information on a phenomenon, a representative case or a random sample may not be the most appropriate strategy (Flyvbjerg, 2006). Table 5.3 summarizes the various forms of sampling. Because the location, type, time, and importance of mosque must be considered in this research as the main criteria in choosing samples. it is followed by the category B (information -oriented selection), and among this category, paradigmatic cases is suitable due to the cases being able to highlight and represent more general characteristics of the resThere are two potential types of case study design proposed by Yin (2009a, p. 46) that is suitable for the current research project – single case and multiple case studies. For this research, multiple case studies were selected, as it will enable the study to show the influence of architectural elements from the Timurid case studies in Mughal case studies. Due to the fact that firstly, during the historical periods, the process of architectural development occurs gradually in different time-steps (start, culmination, and end), and for this research, it is important to find the transition and also the development of Timurid architecture in Mughal buildings. Secondly, it is also difficult to find a mosque from each selected historical period that can be representative of all features of the hypothesis. It is better to select multiple case studies instead of one. Moreover, Yin (2009a, p. 46) stated that the evidence gathered from multiple case studies is often more plausible and compelling, due to the fact that it realizes reliable data in order to produce a robust studyearch hypotheses.

Table 5.3: Strategies for the Selection of Samples and Cases (Flyvbjerg, 2006)

Type of selection	Purpose
Random Selection	To avoid systematic biases in the sample. The sample's size is decisive for generalization
Random sample	To achieve a representative sample that allows for generalization for entire population
Stratified sample	To generalize for specially selected subgroups within the population
Information-oriented selection	To maximize the utility of information from small samples and single cases. Cases are selected based on expectation about their information content.
Extreme/deviant cases	To obtain information on unusual cases, this can be especially problematic or especially good in a more closely defined sense.
Maximum variation cases	To obtain information about the significance of various circumstances for case process and outcome (e.g., three or four cases that are very different on one dimension: size, form of organization, location, budget)
Critical cases	To achieve information that permits logical deductions of the type, "if this is (not) valid for this case, then it applies to all (no) cases".
Paradigmatic cases	To develop a metaphor or establish a school for the domain that the case concerns

Among four categories of design for case studies that was classified by Yin(2009a, p. 46) ; (single case (holistic) were single case (embedded), multiple cases (holistic), multiple cases (embedded). The best type for this research being multiple cases (embedded). Due to the different contexts (India and Persia) and multiple cases in each context, and that the case studied must be selected from Timurid and Safavid periods (Persia), and the early and high phase of the Mughal period (India) (see Figure5.4).

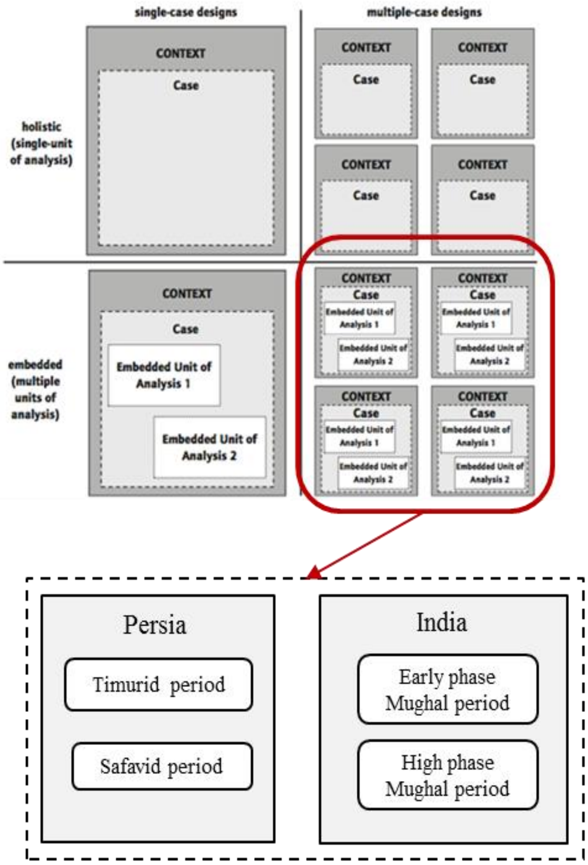


Figure 5.4: Selected type design for case studies of research based on Yin (2009a)

Figure5.5 shows that the proccess of case study from the level of case study selection until the write up to the conclusion regarding the view of Yin(2009a) . Each case study must be conducted separately with individual reports, and must then be analyzed independent of each other. After that, all analyses must be compared in different phases.

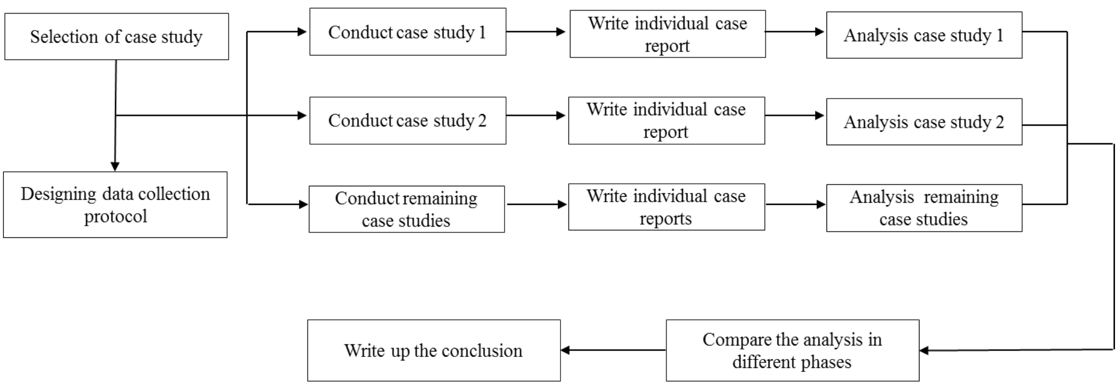


Figure 5.5: Case study process based on the view of Yin (2009a) (Author-2012)

5.7. Data collection

5.7.1. Identification of Case Studies

Based on the results of the first objective realized in chapters 2 and 3 of the literature review, three propositions can be assumed for Timurid architectural transition to Mughal buildings; firstly, via the Indian period that were contemporary of the Timurids. Secondly, direct from Timurid, and finally, via the Persian periods concurrent with the Mughal era. These routes can be classified according to early and high Mughal phases. In this research, due to the vastness of all routes and limited time, propositions that were assumed to be via Persian periods to Mughal era were emphasized. The second and third channels can be selected to continue the research. Figure5.6 shows refined distribution of Timurid propositions to Mughal buildings for choosing case studies. Therefore, the case studies must be selected from Timurid, Safavid, and Mughal periods.

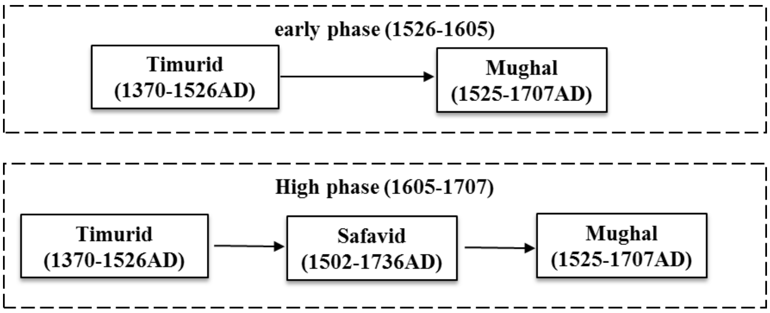


Figure 5.6: Refined distribution of Timurid propositions to Mughal buildings based on early and Mughal phases for choosing case studies (Author-2012)

The main limitation for selecting case studies is that Timurid, Safavid, and Mughal case studies are located in multiple countries. The territory of Timurid mosques including Iran, Afghanistan, Turkmenistan, and Uzbekistan. Safavid mosques are all located in Iran, while Mughal mosques are located in both India and Pakistan. Due to difficulty in visiting potential samples at all these countries, the case study selects samples from Iran and India to represent Timurid, Safavid and Mughal periods.

The chief criteria for choosing samples are location, similarities (means similar styles between Mughal with Timurid and Safavid mosques), importance, and time. Time is essential to Mughal and Safavid mosques, as the period of Mughal and Safavid case studies are concurrent of each other.

5.7.1.1.Case studies of Timurid mosques

Location: Based on Table A-1 in the Appendix A, only 14 mosques of all Timurid mosques (21) are located in Iran, while others are located in central Asian countries, which make it essential that the Timurid mosques in Iran be selected as the subject of case study.

Similar type: Comparing Timurid and Mughal mosque types were classified by Pereira (1994, pp. 100,231) (Refer to tables C-1 in the Appendix C). The case studies can only be selected from similar types of mosques between Mughal and Timurid. The analogues of the types are presented in Figure5.7.

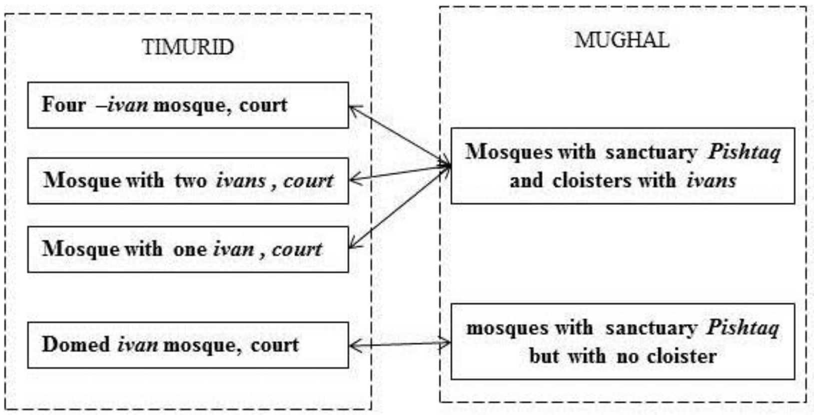


Figure 5.7: Similar Timurid and Mughal type mosque (Author-2012)

Consequently, the mosques that are analogously similar to Mughal mosques includes:

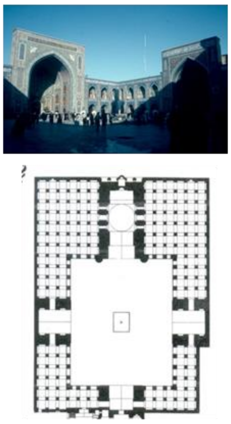
- Mosque with one *Iwan*, court: Shah Vali Mosque, Jami Mosque of Hendovalan.
- Mosque with two *Iwans*, court: Jami Mosque of Varzaneh, Torbat Jam Mosque, Jami Mosque of Abarand, Jami Mosque of Neyshabur
- Four –*ivan* mosque, court: Goharshad Mosque, Maidan Mosque, Darb-i Imam Mosque, Mir Chaqmaq Mosque
- Domed *ivan* mosque(kiosk mosque) court : Mawlana Mosque,

Importance: According to references by the main scholars (Golombek et al., 1988; O'Kane, 1982; pirnia, 2001; Pope, 1965), and among the remained Timurid mosques after deduction based on criteria of location and similar type, only seven of these mosques were mentioned in the Persian architectural references as famous Timurid mosques. Hence other mosques of list must be omitted; Shah Vali Mosque, Jami Mosque of Neyshabur, and Jami Mosque of Hendovalan, Jami Mosque of Abrand.

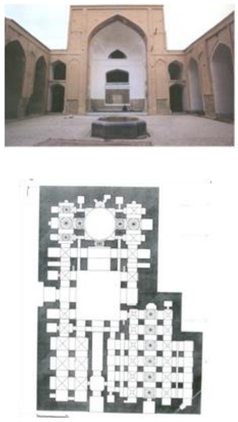
Table 5.4: Selected Timurid mosques based on location, similar type, importance (Author-2012)

No	Name	place	Date of construction	Period
1	**Goharshad Mosque**	Mashhad, Iran	1405-18	Timurid
2	**TorbatJam Mosque**	Torbat-i Jam, Iran	1442-5	Timurid
3	**Mir Chaqmaq Mosque**	Yazd, Iran	1437	Timurid
4	**Mawlana Mosque**	Taybad, Iran	1444-5	Timurid
5	**Darb-i Imam Mosque**	Isfahan, Iran	1453, 1601,1670-71	Timurid ,Safavid
6	**Jami Mosque of Varzaneh**	Varzaneh,iran	1466,1721	Timurid, Safavid
7	**Maidan Mosque**	Kashan, Iran	1468	Timurid, Safavid

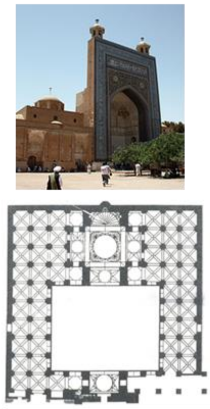
Among the final list of remained Timurid mosque in Table 5.4 , Darb-Imam, Jami Varzane and Maidan Mosques were changed in Safavid period, so these should be omitted. Mawlana Mosque (the sample of domed *ivan* mosque), famous for its tomb and multiple functions (tomb and mosque)(O'Kane, 1979). Its multi-functionality makes it a suitable candidate for elimination. Leaving the rest of the mosques for the Timurid Case, studies (see Figure 5.8): Goharshad Mosque, Mir Chakhmaq Mosque, and Torbat Jam Mosque.



Gaharshad Mosque
(1405-18)
four –*ivan* mosque, court



Mir Chaqmaq Mosque
1437
mosque with four *Ivans*, court



Torbat Jam Mosque
(1442-5)
mosque with two *Ivans*, court

Figure 5.8: Timurid case studies (Author-2012)

5.7.1.2. Safavid case studies

Location, similar type (means similar styles between Mughal with Timurid and Safavid mosques), importance, and time as the main criteria were again repeated in the selection of Safavid case studies.

Location: All Safavid mosques are located in Iran (refer to Table A-2 in Appendix A).

Similar type: Based on the similar Timurid and Mughal mosque types, all Safavid mosques can be classified in this list:

- Mosque with one *Iwan*, court: nothing
- mosque with two *Iwans*, court: nothing

- Four –*ivan* mosque, court: Shah Mosque, Hakim Mosque, No Mosque , Ganj-i Ali Khan Mosque, Khan Mosque
- Domed *ivan* mosque (kiosk mosque) court : Janatsar Mosque, Shaykh Lutfallah Mosque,

Importance: Based on the view of Pirnia (2001), no mosque had undergone significant changes under the Safavid; Ganj-i Ali Khan Mosque bears little importance as a building, while Janatsar mosque forms a small enclosure of the Sheykh Safi complex, and is more renown for the tomb of Sheykh Safi, which prompts the removal of both from the list.

Time matching: The Safavid dynasty (1502-1736AD) was a contemporary of the Mughal Empire (1526-1707AD). Koch(1991b) mentioned that, Safavid architecture has influenced the high Mughal phase, Especially in the period of Shah Jahan. As he was a concurrent of Shah Abbas II –king of Safavid, which means that all Safavid case studies must be selected from periods earlier than Shah Jahan's, narrowing it down to mosques from the periods of Shah Tahmasp, Shah Tahmasb I, and Shah Abbas I that must be omitted from the list (see Figure5.9).

Among the mosques shown inTable 5.5, only three of them remained from total mosques. As a result of this, the best Safavid mosque for the case study is the Shah Mosque in Isfahan, designed according to the four *ivan* mosque with a courtyard (one of similar mosque type) (see Figure5.10).

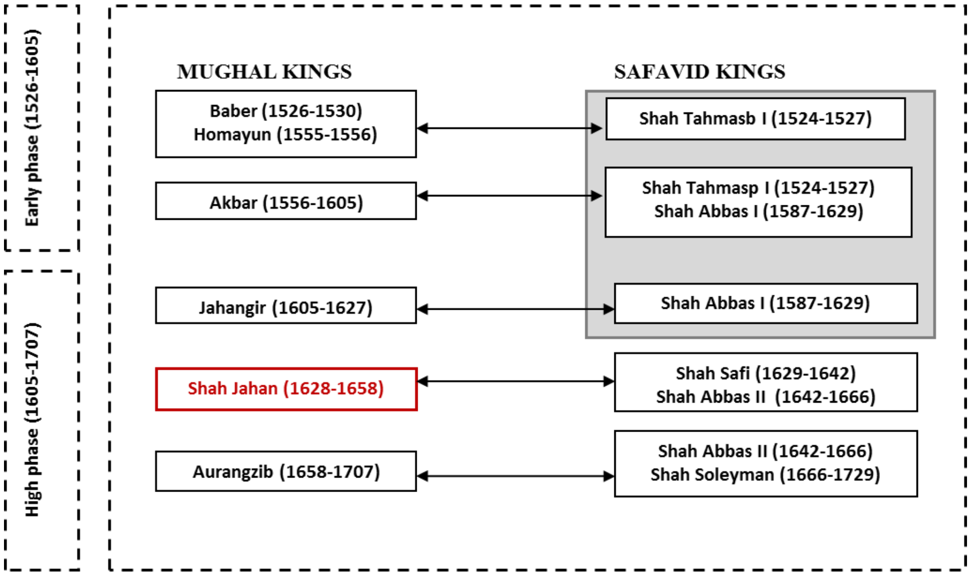


Figure 5.9: Time matching of Safavid and Mughal kings (Author-2012)

Table 5.5: Safavid mosques (refined selection based on type, importance, time) (Author-2012)

No	Name of king	Name	place	Date of construction	Period
1	Shah Abbas I	**Shah Mosque**	Isfahan, Iran	1611-1638	Safavid
2	Shah Abbas I	**Shaykh Lutfallah Mosque**	Isfahan, Iran	1617	Safavid
3	Shah Abbas I	**Khan mosque**	Shiraz , Iran	1627	Safavid

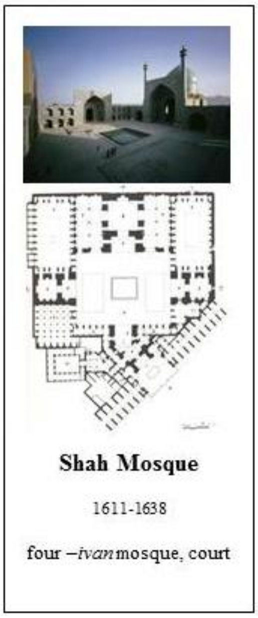


Figure 5.10: Safavid case study (Author-2012)

5.7.1.3. Case studies of Mughal Mosques

According to the literature review (section 2.3.6), Mughal architecture can be divided into two phases (early, high).

Location: Based on Table A-3 in the Appendix A**,** among 25 Mughal mosque distributed in India and Pakistan, only 19 Mughal mosques are located in India.

Similar type: Table C-2 of the Appendix C represents the typology of Mughal mosque based on the view of Pereira (1994, p. 231). Among these mosques types, only"Mosques with sanctuary *Pishtaq* but with no cloister" and "Mosques with both sanctuary *Pishtaq* and cloisters with *ivans* "have similar types with Timurid mosques. These Mughal mosque include:

- Mosques with sanctuary *Pishtaq* but with no cloister: Taj Mahal and Afsarwala Mosque, Ayodha Mosque, Kabuli Mosque, Kachpura Mosque
- Mosques with both sanctuary *Pishtaq* and cloisters with *ivans* :
  - *two Ivans:* Khayr Al-Manazil Mosque , Dargah mosque
  - *three Ivans:* Fatehpur Sikri Mosque , Agra Moti Mosque
  - *Four Ivans:* Agra Jami Mosque. Delhi Jami Mosque, Shah Jahan Mosque,

Importance: based on historical references(Asher, 1992; Koch, 1991b), some of the mosques belonged to Babur kings, and experienced poor constructions, such as the Ayodha mosque. This is one of the reasons that it is omitted from the list.

Time: Based on the result of the first objective in section 3.4, Mughal mosques can be selected separately from the early and high phase shown in Table 5.6 &Table 5.7. Moreover, it can be discerned as the main formative phase of Akbar and Shah Jahan, based on the view of Koch(1991b, p. 15) and Pereira (1994, p. 230), and the fact that

Timurid architecture heavily influenced Mughal mosques of Buber and Humayon kings, therefore, it is better to select case studies from the Akbar king in the early phase. In the high phase, most groups of Persian architecture that have immigrated to the Mughal court worked during Shah Jahan's period (Ziauddin, 2005), thus, mosques constructed during this time suits the purpose of the case studies.

Table 5.6: Mughal mosque in early phase (refined selection based on location, type, importance, and time) (Author-2012)

No	Name of king	Name	place	Date of construction	Period
1	Babur	**Kabuli Bagh Mosque**	Panipat - Haryana	1528-29	Early Mughal
2	Humayon	**Kachpura Mosque**	Agra- Uttar Pradesh	1530-31	Early Mughal
3	Akbar	**Afsarwala Mosque**	Delhi-	1560	Early Mughal
4	Akbar	**Khayr Al-Manazil Mosque**	Delhi	1561	Early Mughal
5	Akbar	**Fatehpur Sikri Mosque**	Fatehpur Sikri	1568-78	Early Mughal
6	Akbar	**Dargah Mosque**	Ajmer-Rajasthan	1570	Early Mughal

Table 5.7: Mughal mosque in high phase (refined selection based on location, type, importance, and time) (Author-2012)

No	Name of king	Name	place	Date of construction	Period
1	Shah jahan	**Shah Jahan Mosque**	Ajmer - Rajasthan	1636	Late Mughal
2	Shah jahan	**Taj Mahal Mosque**	Agra- Uttar Pradesh	1640-50	Late Mughal
3	Shah jahan	**Moti Mosque**	Agra - Uttar Pradesh	1647-53	Late Mughal
4	Shah jahan	**Agra Jami Mosque**	Agra- Uttar Pradesh	1648	Late Mughal
5	Shah jahan	**Delhi Jami Mosque**	Delhi	1650-56	Late Mughal

From each type one mosque was selected that comprise: Taj Mahal mosque, Khayr Al-Manazil Mosque, Fatehpur Sikri Jami Mosque, Delhi Jami Mosque. After study trip to India, the second one was omitted due to the lack of complete measured drawing documents. Figure 5.11 shows the final list of Mughal case studies.

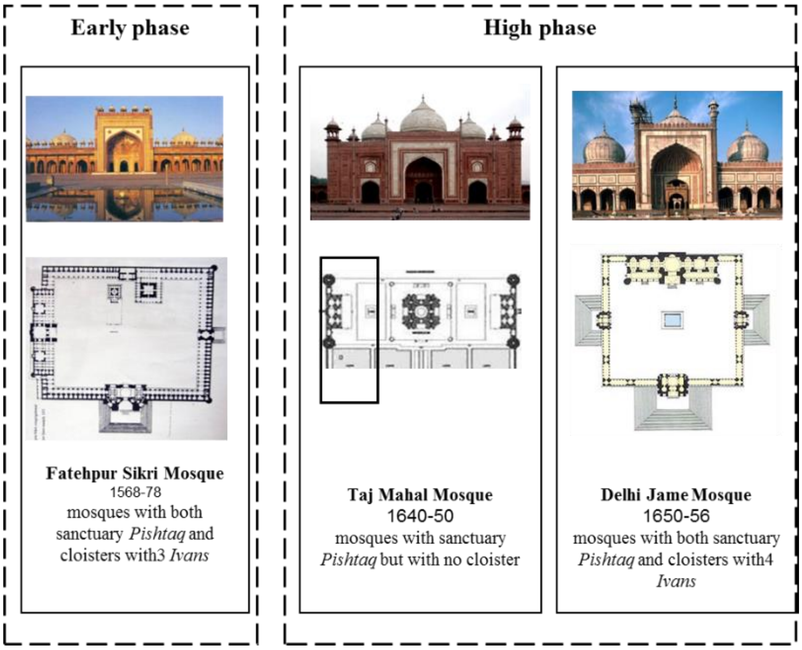


Figure 5.11: Mughal case studies (Author-2012)

Finally, Figure 5.12 represents the sequence of selection case studies based on four criteria (location, similar type, importance, time).and also Figure 5.13 shows that the geographical distribution of all case studies (Timurid , Safavid, Mughal) in contemporary countries (Iran and India).

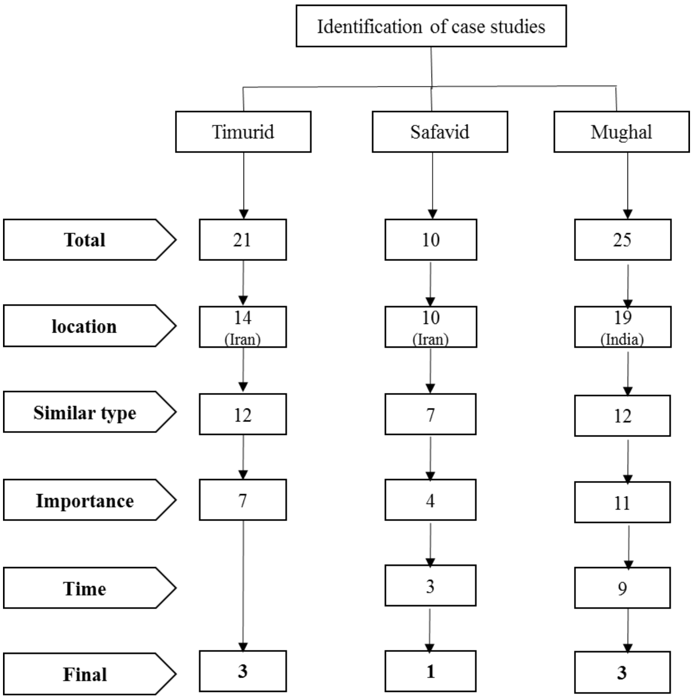


Figure 5.12: The sequence of selection case studies based on location, similar type, importance, time (Author-2012)

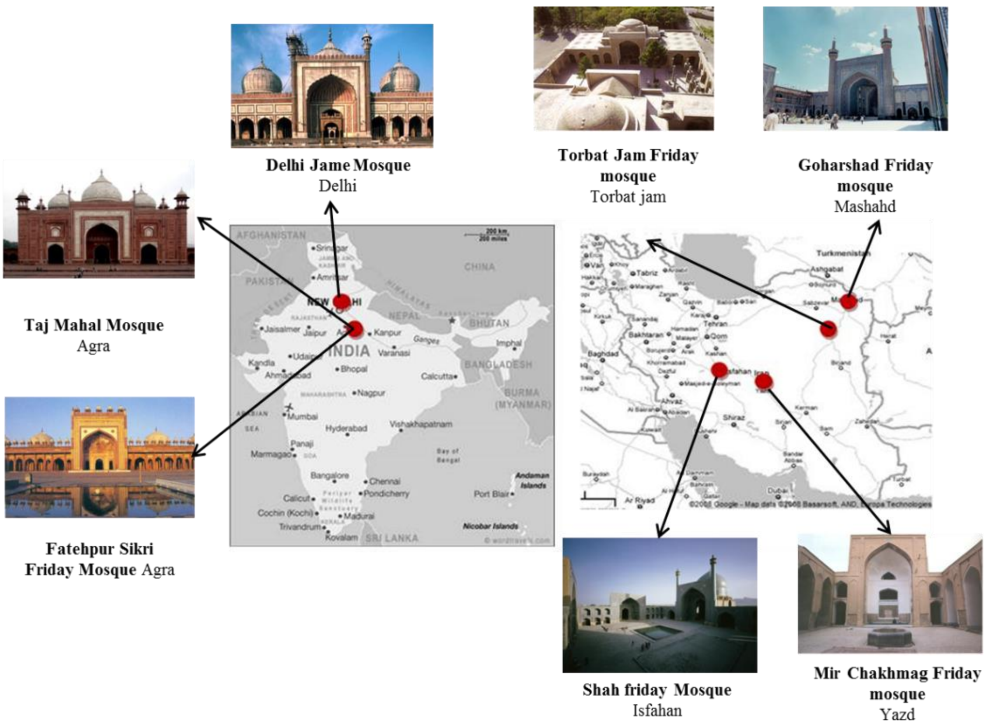


Figure 5.13: Geographical distribution of all case studied in Iran & India

5.8. Source of Evidence for Case Studies

Yin(2009a, p. 101)and Gillham(2000, p. 21) explained that the sources of evidence are the ones most commonly used in conducting case studies: documentation, archival records, interviews, direct observations, participant-observation, and physical artifacts. Moreover, Creswell (2012, p. 182) mentioned four data collection approach in qualitative research that encompass observation, interviews, documents, audiovisual materials. The useful sources for this research comprises of documentation, direct observation, and audiovisual materials.

5.8.1. Triangulation (Use multiple source of evidence)

The use of multiple sources of evidence in case studies allows an investigator to address broader historical and behavioral issues. The most important advantage of using multiple sources of evidences is the development of converging lines of inquiry (Yin, 2009a). Documentation, direct observation, and audiovisual materials will be used in the each case study of research; Figure 5.14 presents the process of case studies highlight the sequence of source evidences.

The source of evidences in this research involves:

- ***Documentation:*** documentary information is likely to be relevant to every case study topic exclusion preliterate societies(Yin, 2009a) . For this research, the most useful documentation are architectural measure for each case studies (from governmental or personal documents) and administrative documents (are unpublished information about case studies). All of the measures drawing of seven case studies are available in historical books and heritage organization of both Iran and India. Moreover, measure drawings were confirmed using information from historical references.

Groat & Wang (2013, p. 154) mentioned historical evidences as documentations that are categorized into four types of historical evidences: Determinative, Textual, Inferential, Recollected. These are useful for arch historical research.

- ***Direct observation:*** Because the case study take place in the natural setting of the "case", it is better to create the opportunity for direct observation. This can involve side walk activities, and less formally, direct observation via a field visit(Yin, 2009a). Gillham (2000, p. 54) said that the information of this type is mainly descriptive and interpretative, and largely informal and flexible. In this research, the best approach is to visit the historical mosques outlined in the case studies. One of useful instrument is measuring the buildings directory, and due to the lack of access to buildings surveying and the availability of historical measure drawing, this level was foregone, and the only observation was done based on the check list for each Persian architectural elements (domed chamber, *ivan*, double dome, *squinch*, pointed arch)
- **Audiovisual materials*:*** Capturing images are the main task when visiting these sites during field trips. Some of the spaces require special pictures, and these can either be taken on site , or obtained from personal or public archives. In certain places, such as the Gohar Shad mosque (first Timurid case study), taking photograph is not allowed on site, which forces the author to rely on pictures from closely representative mosques (Astan Ghods Razavi foundation-Mashhad).

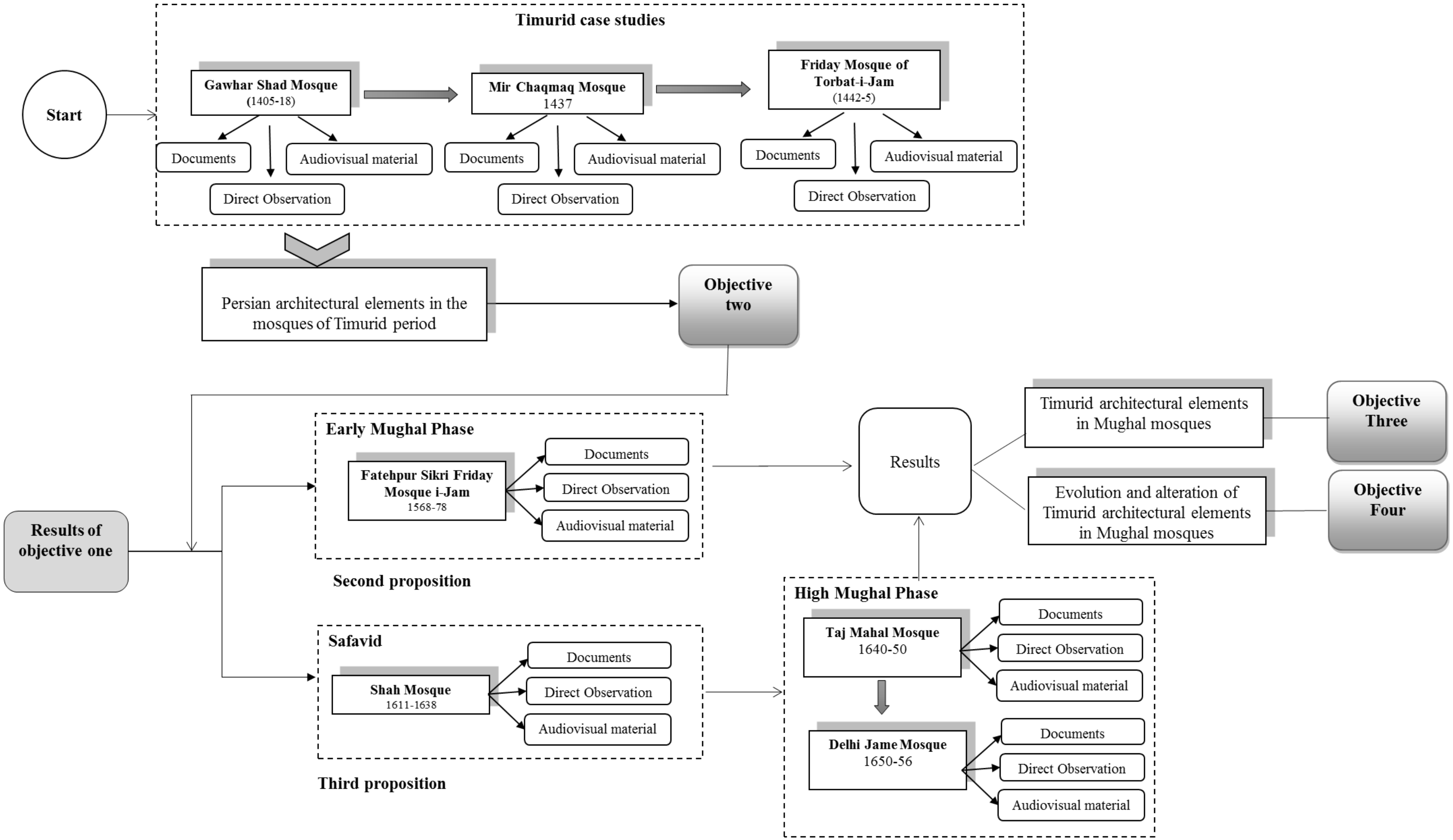


Figure 5.14: Process of case studies with emphasize of sequence of source evidence (Author-2012)

5.9. Study Trip

The first trip involved going to Iran in the period between 20 August to 14 September 2012, visiting Mashahd, Isfahan, Yazd, Torbat Jam, Taybad. This was followed by a visit to India between 17 September to 7 October 2012, at Delhi and Agra. This trip involved measure drawing organizations (refer to table B-1 in the Appendix B) and direct observations of the mosques and libraries, moreover sample of checklist that were filled by the researcher during the visiting each case study (refer to Table B-2 in the Appendix B).

Moreover, the author consulted some Iranian and Indian scholars during the field trip. From Iran, the researcher visited and consulted with Dr. Hossein Soltan Zadeh[3] (head of department of architecture, Azad Islamic university, Ghazvin Iran) twice, in August 2011 and the first week of September 2012. For the first time, he emphasized the necessity of doing similar research for showing the importance of Timurid period. In the next meeting, he checked the case studies and ten Persian elements, and then advised that for a more detailed research, it is better to work elements that are more important in the subject.

In India, the author consulted Prof .Dr**.** Nuzhat Kazmi (Professor of Department of Art History & Art Appreciation, Faculty of Fine Art, Jamia Millia Islamia) and Prof.Dr. Nezhat Kazmi **(**professor of architectural conservation, school of planning and architecture, New Delhi) in October 2012. These two scholars are experts in Mughal architecture. Dr. Kazmi mentioned that it is better to find the historical manuscripts that

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[3] He wrote several articles and books on Persian architecture, and also translated two books on Indian architecture; Mughal Architecture: An Outline of Its History and Development, 1526-1858 (Koch, 1991b), Development of design in Indian architecture (Batley, 1973), and also a book on these issue in 2000 AD (Continuity of design of Persian gardens in the Taj Mahal).

belonged to the period of the research in order to prove historical evidence on the influence of Timurid architecture in Mughal mosques. The author searched many manuscripts in the libraries of India and Iran (Jahangir Namah, Akbar Namah, Amal saleh). However, these manuscripts also mentioned the honors, conquests, and works of the kings and his courts, and the researcher did not manage to discover evidences about Timurid architectural influence, especially with regards to Mughal mosques. In the meantime, Prof. Priyaleen Singh suggested that one Mughal case study be omitted (Khayr Al-Manazil Mosque), as this mosque has less influence of Timurid architecture compared to other Mughal case studies.

While doing data collection, the author encountered some limitations such as:

- The lack of complete measure drawing, especially for two Indian mosques, which resulted in their omission from the case study (Khayr Al-Manazil Mosque).
- Prohibition to take pictures in Goharshad mosque (Timurid case study).

5.10. Data Analysis

Yin(2009a, p. 136) suggested five specific methods of analysis of the case studies, involving pattern matching, time series analysis, logic model, cross case synthesis, and explanation buildings. For the purpose of this research, the explanation buildings technique will be applied to analyze the data. The research attempts to explain the how and the why of a relationship between the two aspects of a phenomenon (Mughal and Timurid architecture).

In the most exciting case studies, an explanation building was constructed in narrative form. As such, a narrative cannot be precise; the superior case studies are the ones where the explanation reflected some theoretically significant propositions. Moreover, in multiple case studies, one goal is to build a general explanation that fits each individual case. Even though the case varies in their respective details, the objective is analogous to creating an overall explanation (Yin, 2009a).

In this research, the Persian architectural elements (*Ivan*, domed chamber, double dome, *squinch*, and pointed arch) mentioned in chapter four will be studied in all case studies within three categories: typological, morphological, and geometrical studies.

5.10.1. Morphological Study & Geometrical Study

Functional elements (domed chamber and *ivan*) can be explained in the form of morphological moods, which includes elements of internal façade (domed chamber) and external façade (*ivan*), organization and relation to other behind spaces, the placement in comparison to general behind façade (only *ivan*), and the opening (only domed chamber) (see Figure 5.15).

Geometrical analysis can be studied using Persian geometrical systems mentioned in section 4.3. The number and the relation between these geometrical systems influenced the proportions and ratios of domed chamber and *Ivan* both horizontally (plan) and vertically (façade) (see Figure 5.15).

Morphological study / Geometrical study

Ivan	shape	dimension			Elements of *Ivan "screen"*											material	relation		horizon Placement of ivan to behind facade			Geometrical analysis	
		L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	Mughsura	front	back	flat	plan	Façade

element of *Ivan* screen
1. inscription frieze
2. spandrel
3. band
4. plinth
5. minaret
6. scroll
7. blind arcade
8. open arcade
9. muqarnas
10. squnch net
11. parapet

General analysis of *ivan*

Morphological study / Geometrical study

Domed chamber	shape	dimension			Elements of internal facade: Load bearing		Elements of internal facade: Transition section					relation			opening		material	Geometrical system	
		L	W	H	1	2	1	2	3	4	5	*Ivan*	nave	*Mihrab*	number	dimension		plan	facade

load bearing system
1. blind arcade
2. open arcade

transition system
1. squinch
2. pendative
3. recumbent arch
4. arch net (squinch net)
5. muqarnas

General analysis of domed chamber

Figure 5.15: Illustration of organized analysis of each functional element with focus in morphological and gemotrical division (Author-2012)

5.10.2. Typological Study

Structural elements (double dome, *squinch*) and ornamental elements (pointed arch) need to be typologically studied. Based on the historical background considerations in chapter four, various types of Persian elements were proposed. Typological analysis involves the type and position of elements (only *squinch* and pointed arch), and elements of supporting and transition systems, types of external and internal shell, and also the dome all for domed chambers. Figure 5.16 presents the illustration of organized analysis of these elements, with emphasis on the typological division.

Typological study

type	Supporting system	Transition tier	C**	Type of internal shell		Type of external shell		drum	material	
				type	H*	type	H*	type	outer	inner

*Height from floor to end of dome C** circumference

General analysis of double dome

Typological study

type	material	position		
		Ivan	dome	entrance

General analysis of *squinch*

Typological study

	type	material	Number of center	Position	
				inside	Outside

General analysis of pointed arch

Figure 5.16: Illustration of organized analysis of structural and ornamnetarl elements with focus in typological division (Author-2012)

5.11. Results and Discussions

In the results chapter, the analogous and similarity among case studies will be compared in three phases. The first phase is the comparison between Timurid case studies, the second is the matching Timurid and Mughal case studies at three levels, and the last one is the similarity between Mughal case studies based on Timurid elements (refer Figure 5.17).

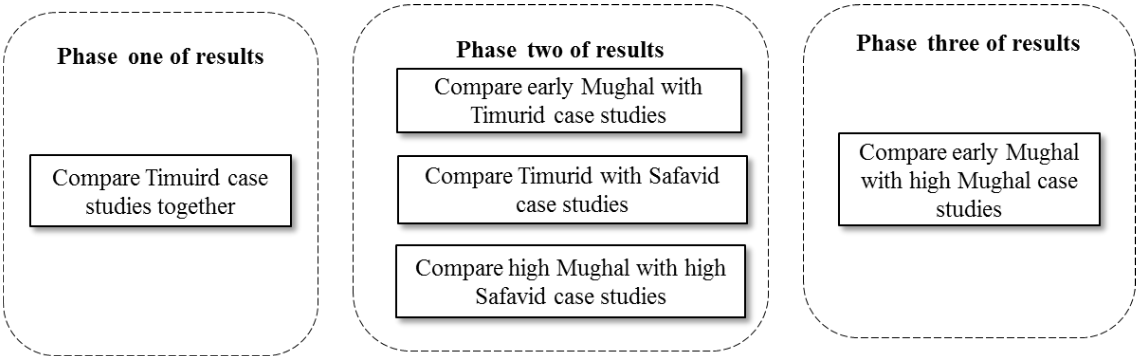


Figure 5.17: Phases of result and discussion chapter (Author-2012)

5.12. Validity (Qualitative Validity)

Validity does not carry the same connotations as it does in quantitative research. Validity, on the other hand, is one of the strength of qualitative research, and it is based on determining whether the findings are accurate from the standpoint of a researcher, the participant, or an account (J. Creswell & Miller, 2000). A procedural perspective that Creswell (2009, pp. 190-192) recommended for research proposal is to identify and discuss one or more strategies available to confirm the accuracy of the findings. There are eight primary strategies, including:

1. Triangulation
2. Use member checking
3. Use rich, thick description
4. Clarify the bias
5. Present negative or discrepant information
6. Spend prolonged time in the field
7. Use peer debriefing

8. Use an external auditor

Among these strategies, the suitable one for this research is triangulation, which means to triangulate different sources and using it to build a coherent justification for the themes. If the themes are established based on converting several sources of data or perspectives from participants, then the process can be claimed as adding to the validity of the study (Barzun & Graff, 1970; J. Creswell, 2012; L. Groat & D. Wang, 2013).

CHAPTER 6: CASE STUDY ANALYSIS

6.1. Introduction

This chapter describes seven case studies from the Timurid, Safavid, (Persia) and Mughal periods (India). The information pertaining to each case study included the description of history, architecture, and analyses based on five Persian architectural elements (that was mentioned in chapter 4's summary). The analyses section was also made up of morphological, geometrical (specific for functional elements; domed chamber and *Ivan*), and typological analyses (for structural elements: double dome & *squinch*, and ornamental element: pointed arch).

These case studies including:

1. Goharshad Mosque –Timuird period
2. Mir Chakhamq Mosque – Timurid period
3. Torbat Jam Mosque –Timurid period
4. Shah mosque –Safavid period
5. Fatehpur Sikri Mosque – Early Mughal period
6. Taj Mahal Mosque – High Mughal period
7. Delhi Jami Mosque – High Mughal period

6.2. First case study: Goharshad mosque

- Location: **Mashhad, Iran**
- Date: **1405-18**
- Building usage: **Jami Mosque**

Figure 6.1: Timurid empire map (created by Arab Atlas)

6.2.1. History

Goharshad mosque is a former free-standing congregational mosque in Mashhad of Khorasan Razavi province (Iran), which now serve as one of the prayer halls within the Imam Reaza shrine complex (Figure 6.1). Shah Rukh, the governor the city of Samarkand, established a new capital at Herat. He was very active as a builder, and in the honor of his new bride whom he married in 1388 (Gohar Shad), he built the immense Jami mosque in Mashhad in 1417(Blunt & Swaan, 1966; Stierlin & Stierlin, 2002).

6.2.2. Architecture

The first and the greatest surviving Persian monuments of the 15th century is the beautiful mosque of Goharshad (1418). It has a courtyard measuring 50m*55m (160 ^{ft} *180 ^{ft}), and the mosque is of the familiar four-*Ivan* courtyard from, containing several *Shabestans(* nave*)* (Pope, 1965). The designer and architect of this mosque was Qavam ad_Din bin Zayn ad_Din Shirazi, a savant of mathematics, designer, and decorator. He was responsible for the construction of the Mosque of Gohar Shad and the shrine of Imam Reza(Stierlin & Stierlin, 2002).

The mosque is known for its tiled mosaic decorations, which was a popular art form during the Timurid dynasty. on a high base of marble revetment , panels of enamel brick and tile works are arranged in two stories that run around the courtyard , capped by a band of calligraphy designed by Gohar shad ‘s son Baysunghur (Pope, 1965).

6.2.3. Analysis

6.2.3.1. Ivans

The main and specific feature of this mosque is four big and high *ivans* with surprising mosaic decoration. The south *ivans* with thick, tower –like minarets merges with the outer corners of the screen and extends to the ground, together with the high foundation revetment of marble, form the turning point in the courtyard. The south *Ivan* was abutted to the domed chamber without any barrier (blind arch or vaulted tunnel), and both of these space are identical in length in a single unit. The depths of *ivans* are irregular, a response to the location of existing buildings where it was inserted. All of the *ivans* were covered by vaulted tunnels (Table 6.1, Figure 6.2 & Figure6.3.).

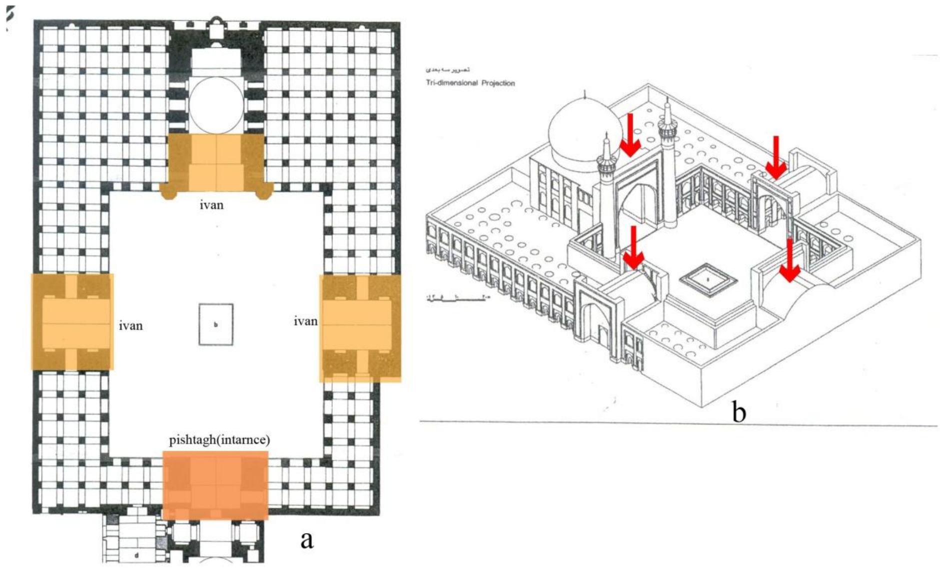


Figure 06.2: Position of *ivans* a) in pelan b) 3-D view . Ref of measure drawing (Amini kiasari, 2010)

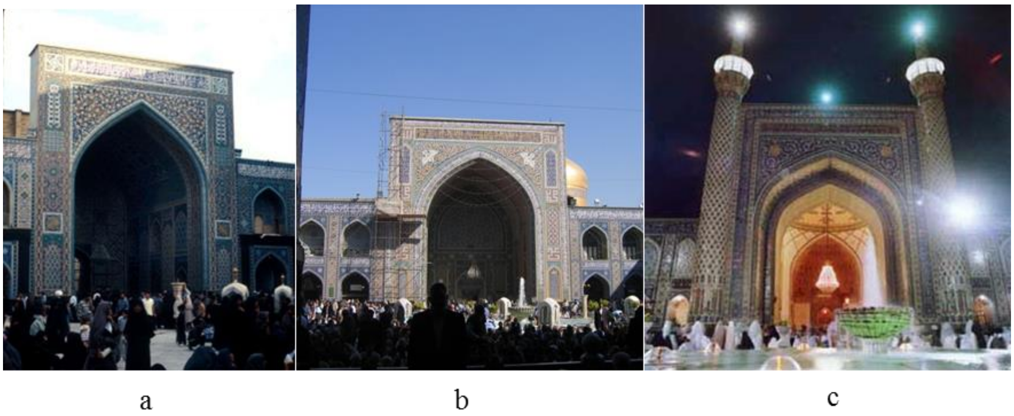


Figure 6.3: a) East & west *Ivans, b*) North *Ivan, c*) South *ivan*
(Razavi, 2005)

Figure 6.4 , Figure 6.5 and Figure 6.6 showed that the geometrical analyses for both plans and façade of the *ivans* were based on Persian geometrical patterns (that was mentioned in 5.5). Among these patterns, patterns three and four were used for the south Ivan, while patterns one, three, and four were used for the other *ivans* in a horizontal manner. Moreover, patterns one and eight can be seen for all *ivans*, while patterns two and five can be seen from the south *ivan* in a vertical manner.

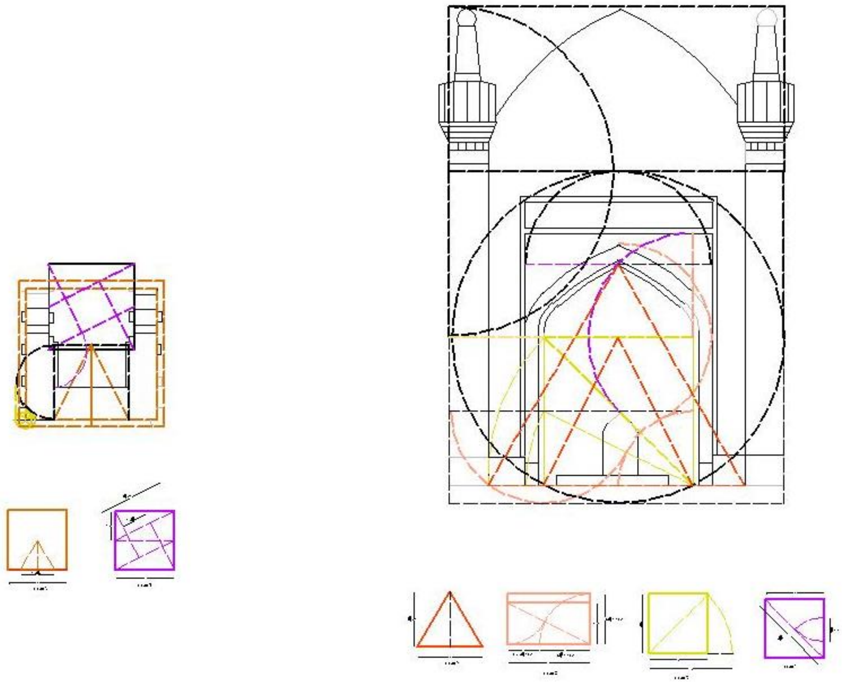


Figure 6.4: Geometrical analysis of: south Ivan plan (left), south Ivan façade (right)
(Author-2012)

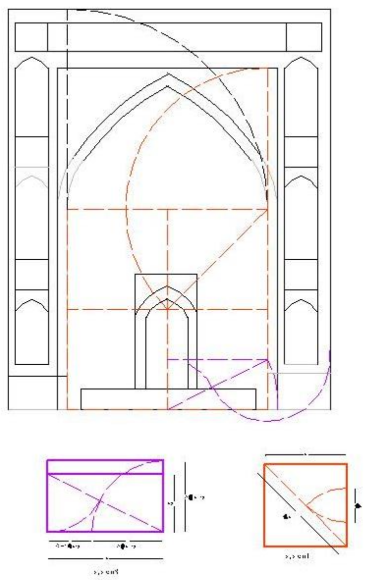


Figure 6.5: Geometrical analysis plan of: north Ivan (left), east& west Ivan (right) (Author-2012)

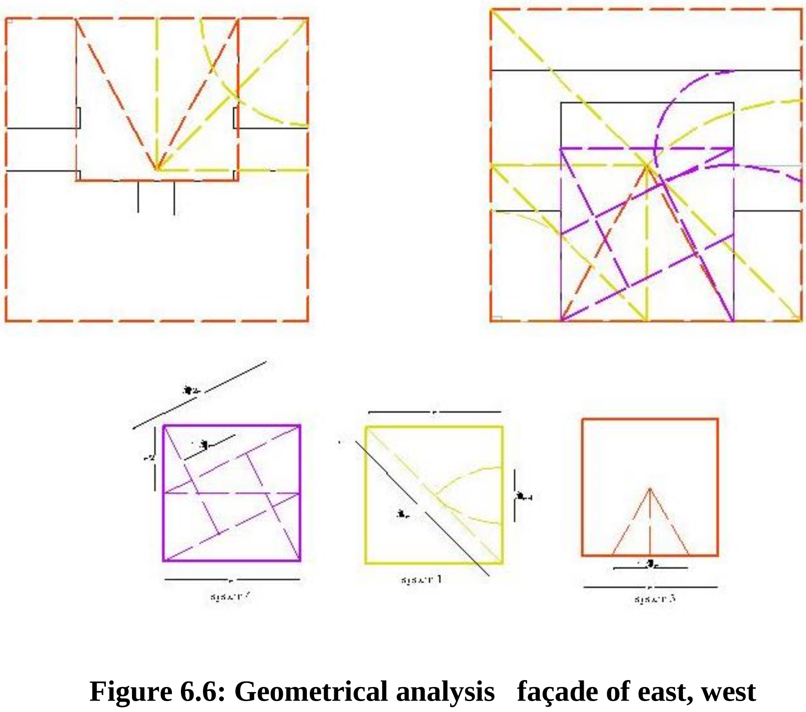


Figure 6.6: Geometrical analysis façade of east, west & north *ivans* (Author-2012)

Table 6.1: General analysis of Ivans(Author-2012)

Ivan	shape	dimension			Elements of *Ivan “screen”*											material	relation		Location of the facade			Geometrical patterns	
		L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	Domed chamber	front	back	flat	plan	Façade
South *Ivan*	rectangular	36	18	36	✓	✓	✓	✓	✓			✓				Mosaic faience		✓	✓			3,4	1,2,5,8
North *Ivan*		31	25	34	✓	✓	✓	✓				✓					✓				✓	1,3,4	1,8
East *Ivan*		31	25	34	✓	✓	✓	✓				✓					✓				✓	1,3,4	1,8
West *Ivan*		31	25	34	✓	✓	✓	✓				✓					✓				✓	1,3,4	1,8

element of *Ivan* screen

1.inscription frieze
2.spandrel
3.band
4.plinth
5.minaret
6.scroll
7.blind arcade
8.open arcade
9.muqarnas
10.squnch net
11.parapet

6.2.3.2. Domed Chamber

Table 6.2 : General analysis of domed chamber(Author-2012)

Domed chamber	shape	dimension			Elements of internal facade							relation			opening	material	Geometrical pattern	
					Load bearing		Transition section										plan	Façade
		L	W	H	1	2	1	2	3	4	5	*Ivan*	nave	*Mihrab*				
	Square	20	20	29	1	6	✓			✓		✓	✓	✓	_	plaster	3,4,5,8	1,4,5

load bearing system

1.blind arcade
2.open arcade

transition system

1.squinch
2.pendative
3.recumbent arch
4.arch-net (*squinch*-net)
5.muqarnas

The domed chamber was surrounded by open arcades of sanctuaries in the east and west sides, despite the fact that it is liberally integrated and combined with the south *Ivan*, while the *Mihrab* in the south and north sides looked the way they do due to the identical length of their respective components. Moreover, there are no delimiters between the domed chamber and the south *Ivan*, which makes the domed chamber, *Ivan*, and *Mihrab* appear as a unit of combination (Table 6.2, Figure 6.7 & Figure 6.8).

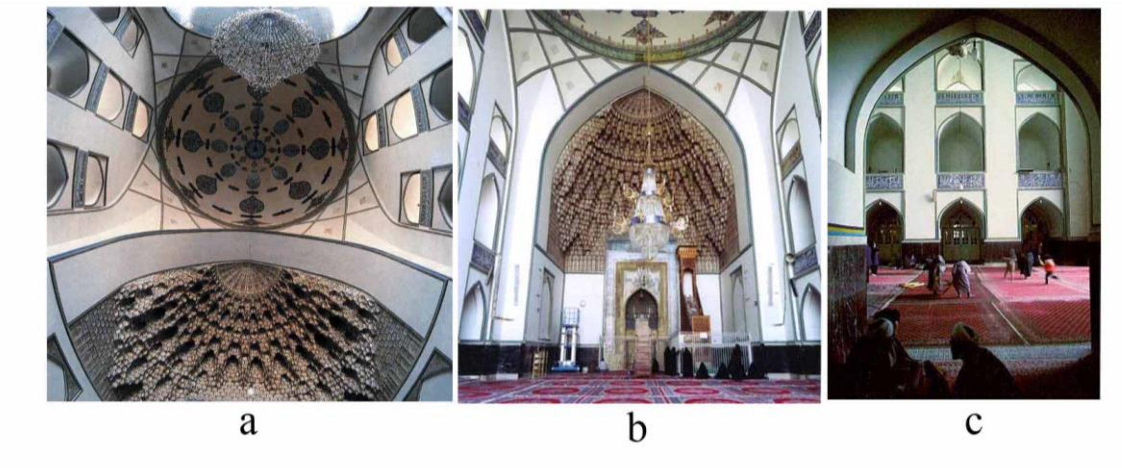


Figure 6.7:a) Ceiling of domed chamber, b) *Mihrab*, c) Cpen arcade of load bearing section(Razavi, 2005)

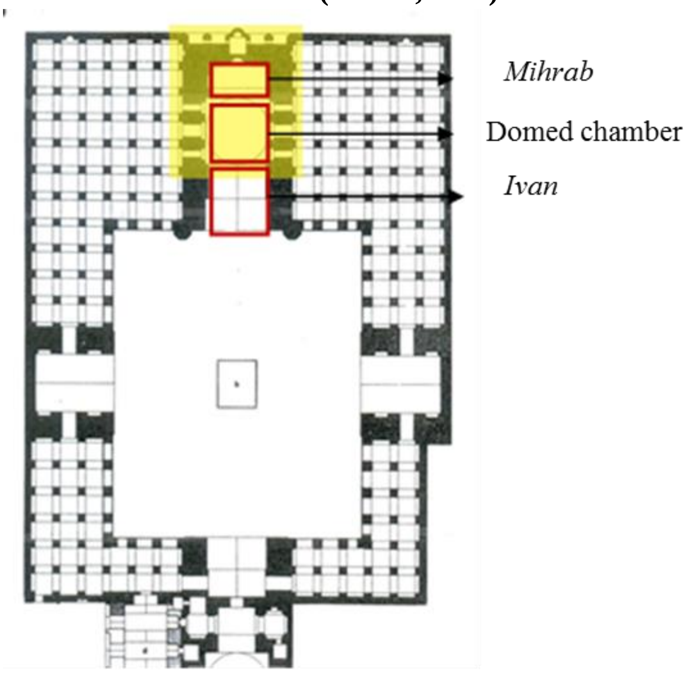


Figure 6.8: Combination domed chamber, *Ivan, Mirab*
ref of measure drawing(Amini kiasari, 2010)

Figure 6.9 & Figure 6.10 shows that geometrical analyses for both the plans and façades of the domed chamber are based on Persian geometrical patterns. Among these patterns, patterns four and five were used for the domed chamber both in a horizontal and vertical manner, while pattern one was specifically applied to the façade and patterns three and eight are visible in the façade.

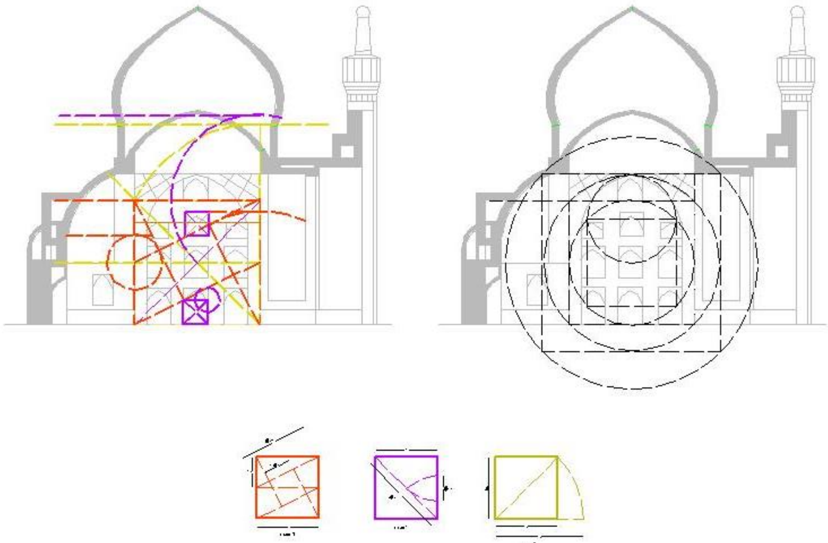


Figure 6.9: Geometrical analysis section of domed chamber (Author-2012)

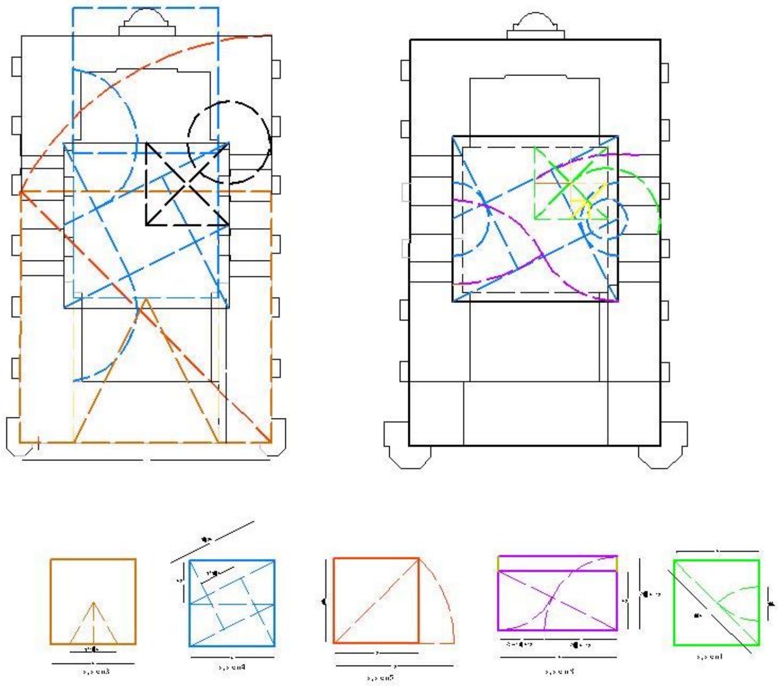


Figure 6.10: Geometrical analysis of combination domed chamber, *Ivan, Mihrab* (left), Geometrical analysis of domed chamber (Author-2012)

6.2.3.3. Double Dome

The main dome of Goharshad mosque founds two dissociated onion –like layers within a short shaft and a hatchway diameter of 15 m , a circumference of 63 m, and a thickness of 5.2 m. the convex part pf the dome 's shell is ornamented with an inscription Witten in Kufic script (Figure 6.11, Figure 6.12, Figure 6.13&Table 6.3).

Table 6.3: General analysis of double dome (Author-2012)

type	Supporting system	Transition tier	C**	Type of internal shell		Type of external shell		drum	material	
				type	H*	type	H*	type	outer	inner
Discontinuous double dome	Square with bearing wall	squinch	62	Semi circular	29	Bulbous	54	Cylinder	Fiancé Mosaic	Plaster

*Height from floor to end of dome C** circumference

a b c

Figure 6.11: Double dome :a) internal ceiling, b & c) external dome(Razavi, 2005)

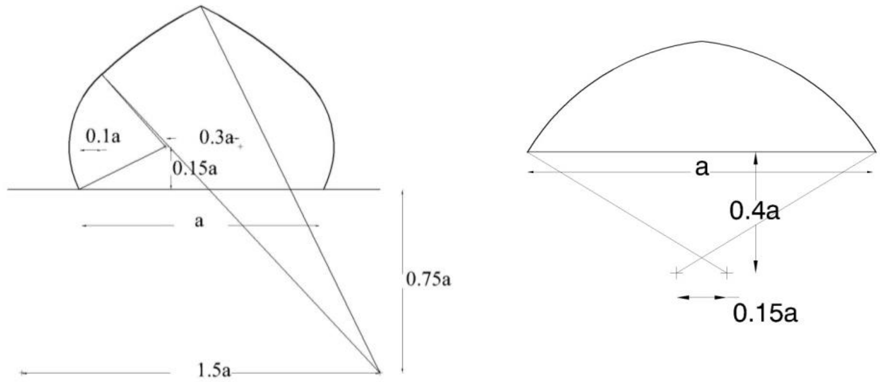


Figure 6.12, Geometrical analysis Of: external shell (left), internal shell (right) (Author-2012)

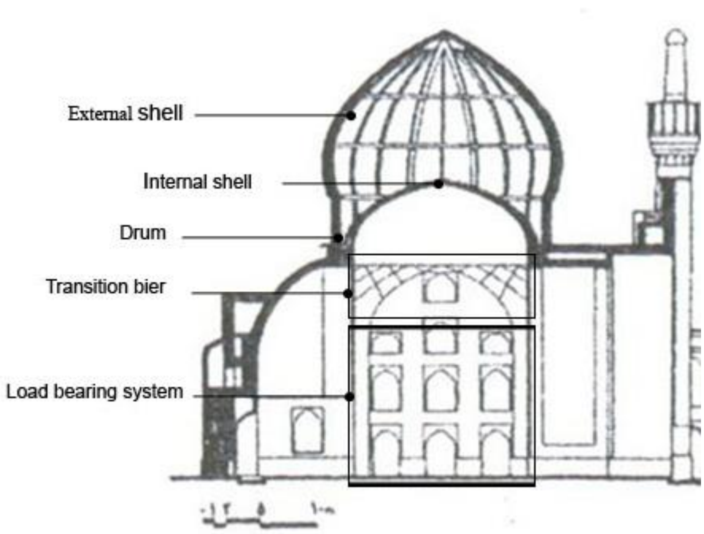


Figure 6.13: Transversal section, ref of measure drawing(Amini kiasari, 2010)

6.2.3.4. Squinch

The corner element of the transition system may be the simplest type of *squinch*, which is a beam, lying across the corner resting on tangent walls, but it is concealed behind a "*sqiunch* net" (arch-net as plaster revetment). There is doubt about the functional transitional element, whether it might be a simple *squinch* or *pendative (*Table 6.4 , Figure 6.14 & Figure 6.15).

Table 6.4: General analysis of *squinch* (Author-2012)

type	material	Location		
		Ivan	dome	entrance
A beam across the corner with plaster revetment of arch-net	Plaster		✓	

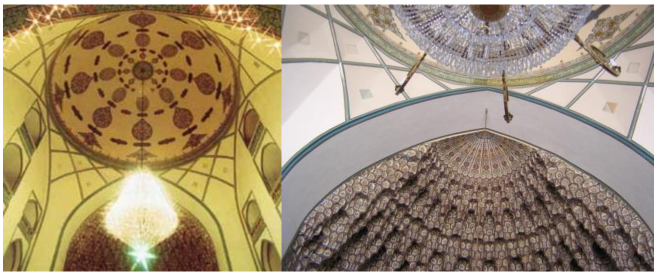


Figure 6.14: *Squinch* net of dome (Razavi, 2005)

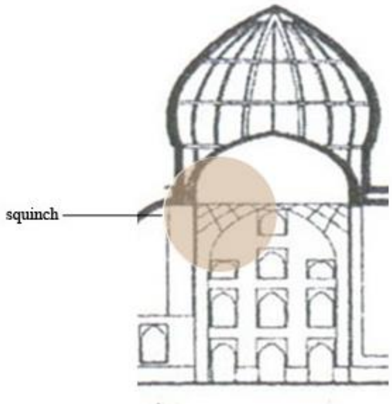


Figure 6.15: *Squinch* –net , ref of measure drawing (Amini kiasari, 2010)

6.2.3.5. Pointed Arch

With regards to Figure 6.17, Figure 6.19, and Table 6.5 and comparison with Persian pointed arch (that was mentioned in 4.4.6, and see Figure 4.22), it can be seen that type 3-1 of the pointed arch (that is categorized as a load bearing arch) was used in the south *ivan* and domed chamber vault. Type 4-1 pointed arch was applied to cover small spaces, such as other *ivans* and façade yards.

Table 6.5: General analysis of pointed arch (Author-2012)

	type	material	Number of center	Location	
				inside	Outside
1	Type 3-1	Mosaic faience	4		South *Ivan*
2	Type 3-1	plaster	4	Domed chamber vault	
3	Type 4-1	Mosaic faience	4		North *Ivan*
4	Type 4-1	Mosaic faience	4		West & east *Ivan*
5	Type 4-1	Mosaic faience	4		Façade yard

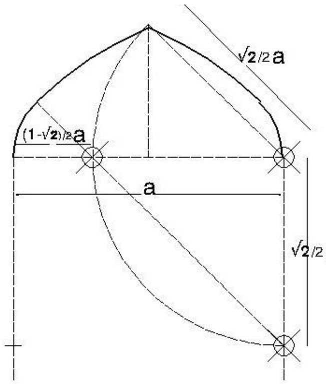


Figure 6.16: Type 3-1 of Persian pointed arch(Pirnia, 1991)

Figure 6.17, Arch of domed chamber's vault(left), arch of south *Ivan* (right) (Razavi, 2005)

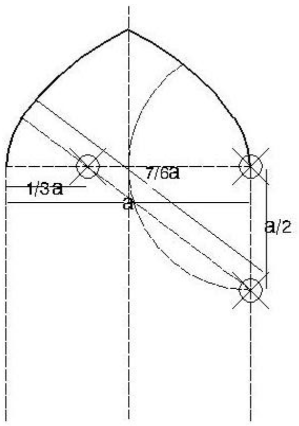


Figure 6.18, Type 4-1of Persian pointed arch(Pirnia, 1991)

Figure 6.19, Arch of east, west, north Ivan (Razavi, 2005)

6.3. Second case study: Mosque of Mir Chakhmaq

- Location: **Yazd, Iran**
- Date: 1436-7
- Building usage: **Mosque**

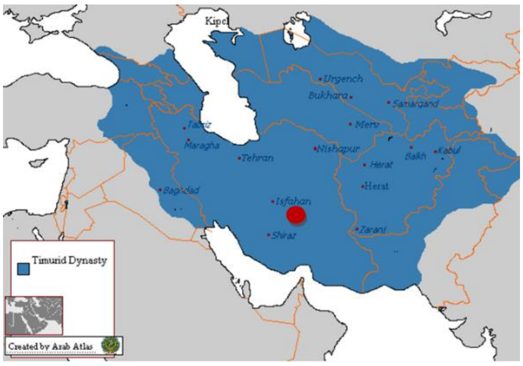


Figure 6.20: Timurid map (created by Arab Atlas)

6.3.1.History

The mosque of Mir Chaqmaq, which is located in Yazd (central part of Persia), also referred to as the Masjid-e Nau. It was one of the first constructions in a larger institutional complex consisting of a *madrasa* (theological school), *khanqah* (a hostel for *sufis* or dervishes), caravanserai (traveler's inn), *qanat*, and *ab anbars* (subterranean canal and water cistern), public baths, *meidan* or public square and bazaar sharing the same name (Figure 6.20). Today, only the mosque, *meidan*, and a few hydraulic structures remains from the original complex (Golombek et al., 1988).

Construction of the mosque was started by Jalal Al-din Chaqmaq Shami, the governor of Yazd under the Timurid ruler Shah Rukh in 1436-7, and completed some years later through the active patronage of Bibi Fatima Khatun, wife of Mir Chaqmaq. The masjid represents, in the context of Yazd, a larger phenomenon of Timurid patronage of madrasa-*Khanqah* complexes as a unifying and propagandistic strategy to control a large and diverse empire (Ernst, 1992).

6.3.2. Architecture

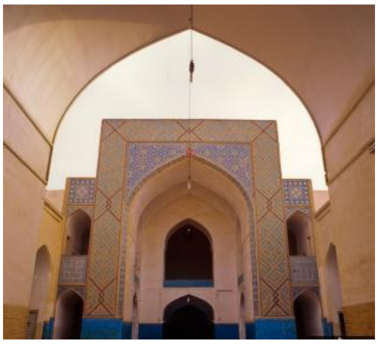
The mosque influences subsequent Islamic architecture of central Persia with its introduction of a shorter *Ivan*, covered with a cloister vault. This mosque used the popular model of Persian four-*Ivan* structure, around a square courtyard with no minarets. The mosque also features a novel innovation in incorporating a wind tower within the *mihrab* , and is also noted for the excellence of decorative craftsmanship on its marble *mihrab* (niche marking the direction of prayer in a mosque) and its portal 's tile mosaic calligraphic panels (Golombek et al., 1988).

The mosque is built using mud bricks, with white washed plaster finish. The central *mihrab* contains of marble with decorative mosaic tile borders and *quranic* inscriptions. The celebrated portal is decorated with masterfully stucco and calligraphic friezes. Panels of mosaic faience or glazed tile mosaic in blue , yellow , white and black are interspersed within patterned brickwork facades , as is typical of early Timurid decorative arts (Hillenbrand, 1999).

6.3.3. Analysis

6.3.3.1. Ivans

Despite the small size of courtyards, the mosque was designed according to four *ivans*. The main *ivan* was bigger and deeper than the other *ivans*. All *ivans* were related to the naves, domed chamber (south *ivan*), and main corridors (north and east *ivans*) by vaulted tunnels. The main material of the *ivans* is mosaic faience (blue, yellow, white, black) within patterned brickworks (see Table 6.6, Figure6.21 &6.22).



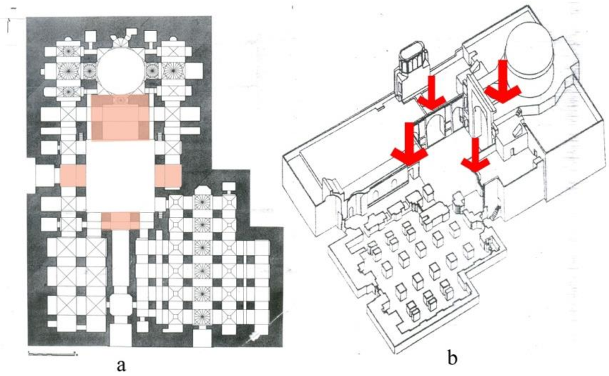


Figure 6.21: South *Ivan* (Author-2012)

Figure 6.22: Position of Ivans a) in pelan b) 3-D view . ref of measure drawing(Golombek et al., 1988)

Figure 6.23, 6.24 & 6.25 showed that the geometrical analyses for both plans and façades of *ivans* are based on Persian geometrical patterns. Among these patterns, patterns one, two, five, and eight were used for all *ivans* in a vertical manner, while pattern four was used only for the south *ivan*. Patterns one, three, and four are present in the plan of all the *Ivans*.

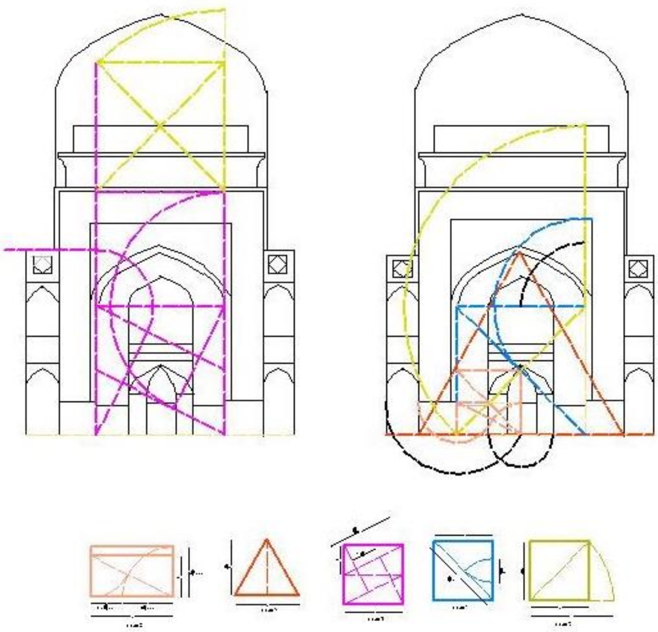


Figure 6.23: Geometrical analysis façade of south *ivan* (Author-2012)

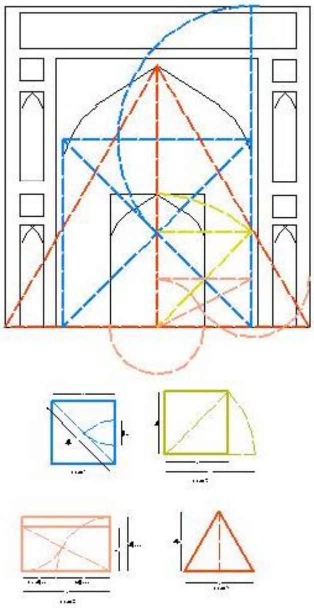


Figure 6.24: Geometrical analysis of south *ivan* (Author-2012)

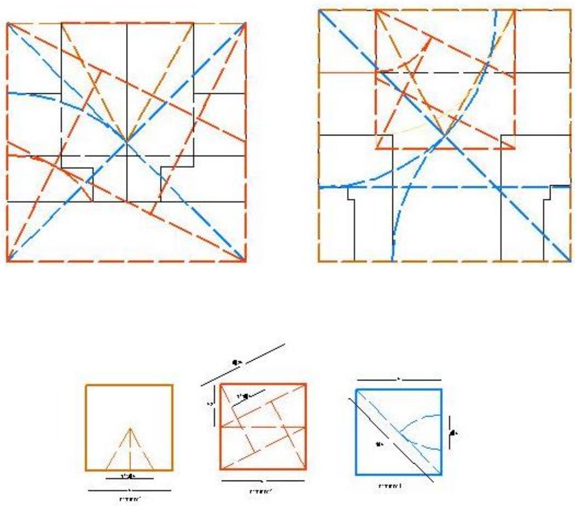


Figure 6.25: Geometrical analysis of: north *ivan* plan (left), b) East & west *ivans* plan (center), Façade of east & west &north *ivans* (right) (Author-2012)

Table 6.6 : General analysis of Ivans (Author-2012)

Ivan	shape	dimension			Elements of *Ivan "screen"*											material	relation		Location of the facade			Geometrical patterns	
		L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	Domed chamber	front	back	flat	plan	Façade
South *Ivan*	rectangula r	13	10.5	15		✓	✓	✓				✓				Mosaic faience		✓			✓	1, 3,4	1,2,4,5,8
North *Ivan*		8.6	6	8.5	✓	✓	✓	✓				✓					✓				✓	1,3,4	1,2,5,8
East *Ivan*		10	7	10	✓	✓	✓	✓				✓					✓				✓	1,3,4	1,2,5,8
West *Ivan*		10	7	10	✓	✓	✓	✓				✓					✓				✓	1,3,4	1,2,5,8

element of *Ivan* screen

1.inscription frieze
2.spandrel
3.band
4.plinth
5.minaret
6.scroll
7.blind arcade
8.open arcade
9.muqarnas
10.squnch net
11.parapet

6.3.3.2. Domed Chamber

Table 6.7 : General analysis of domed chamber(Author-2012)

Domed chamber	shape	dimension			Elements of internal facade							relation			opening	material	Geometrical pattern	
					Load bearing		Transition section										plan	Façade
		L	W	H	1	2	1	2	3	4	5	*Ivan*	nave	*Mihrab*				
	Square	12.2	12.2	18.3	5	14	✓			✓		✓	✓	✓	_	plaster	1,3,4,5	1

load bearing system

1.blind arcade
2.open arcade

transition system

1.squinch
2.pendative
3.recumbent arch
4.arch-net (*squinch*-net)
5.muqarnas

The domed chamber design is based on squares. It is linked to the nave via three vaulted tunnels, with the size of the middle tunnel serving as the focal point of the structure. The inertial façade are symmetrical to each opposite sites. The dominant material in this case is plaster, with a panel of blue glazed tile mosaic, emphasizing horizontal elements. The load-bearing system is based on typical Persian design that includes blind arch-main open arch and blind arches (refer to Figure 6.26 , Figure 6.27 &Table 6.7).

Figure 6.26: a) Corner of domed chamber, b) *Mihrab*, (Author-2012)

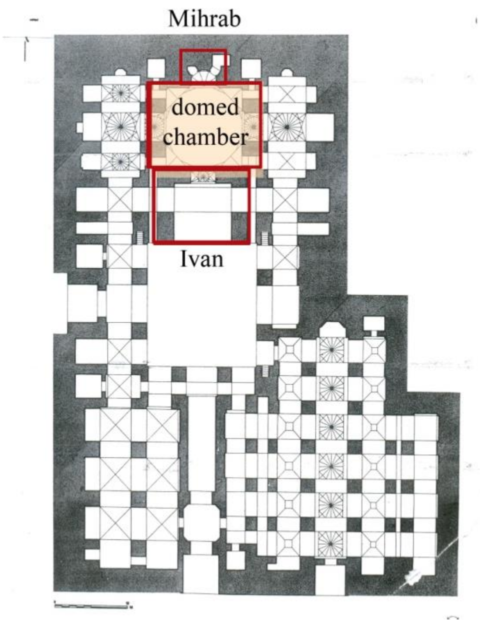


Figure 6.27: Combination domed chamber, Ivan, *Mirab*, ref of measure drawing(Golombek et al., 1988)

Figure 6.28 & 6.29 displays the geometrical analyses for both plans and façades of a domed chamber based on Persian geometrical patterns. Among these patterns, patterns one, three, four, and five abide by the plan, with only pattern one present in the façade.

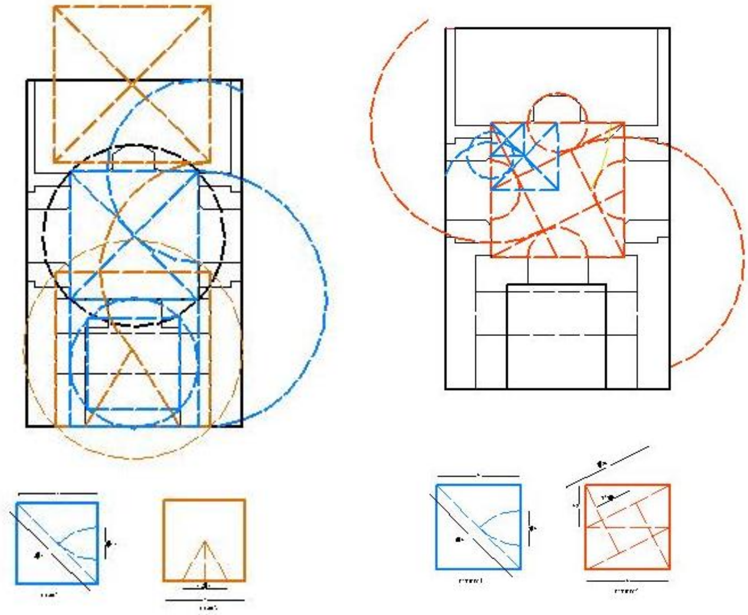


Figure 6.28: Geometrical analysis: a) Combination domed chamber, Ivan, *mihrab*, b) Domed chamber (Author-2012)

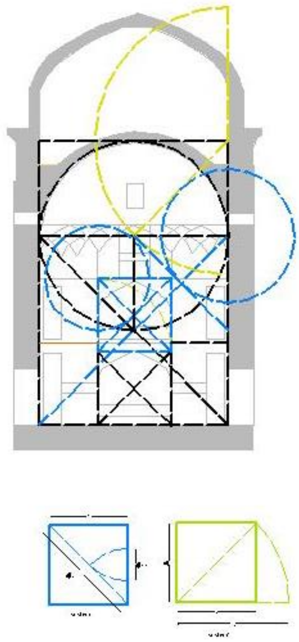


Figure 6.29 : Geometrical analysis section of domed chamber (Author-2012)

6.3.3.3. Double Dome

The dome was composed of discontinuous double domes with pointed arch for the external shell, and two –tiered circular drum , embellished with bands of mosaic tile inscription in Kufic script . The dome has a hatchway with a diameter of 12 m, and a circumference of 38 (see Table 6.8, Figure 6.30 , 6.31 &6.32).

Table 6.8 : General analysis of double dome (Author-2012)

type	Supporting system	Transition tier	C**	Type of internal shell		Type of external shell		drum	material	
				type	H*	type	H*	type	outer	inner
Discontinuous double dome	Square with bearing wall	Squinch+ arch-net	38	circular	18.3	pointed	27	Cylinder	Fiancé Mosaic	Plaster

*Height from floor to end of dome C** circumference

Figure 6.30: External shell of double dome (Author-2012)

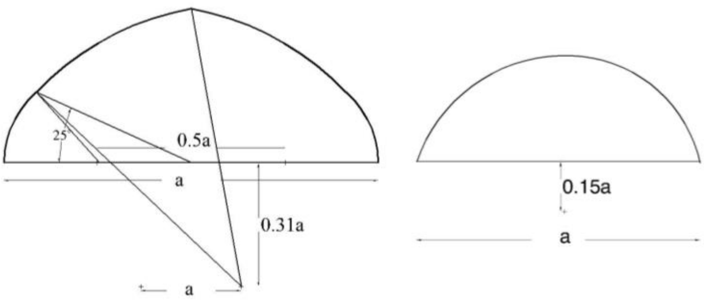


Figure 6.31: Geometrical analysis of: external shell (left), internal shell (right) (Author-2012)

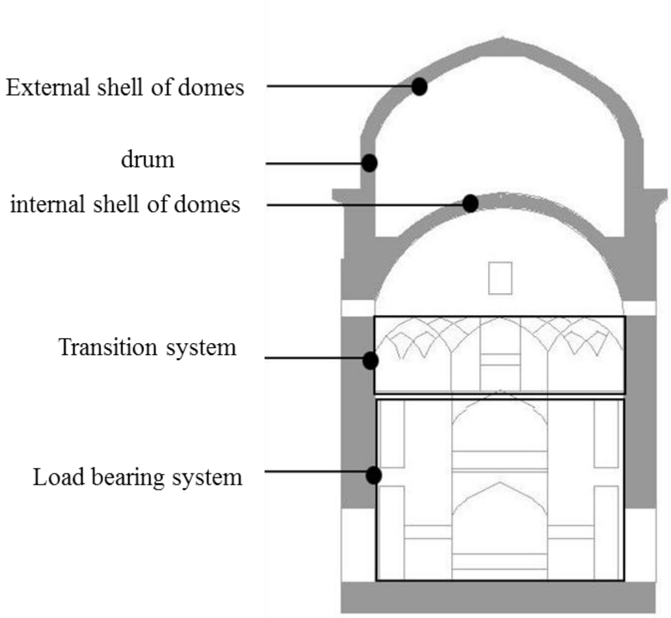


Figure 6.32: Transversal section, ref of measure drawing (Golombek et al., 1988)

6.3.3.4. Squinch

The *squinch* was formed by a groined vault, was elaborated internally by a *squinch*–net (arch-net). The whole of the element becomes part of the octagonal plinth, over which the dome was built (see Figure 6.33 &Table 6.9).

Table 6.9: General analysis of *squinch* (Author-2012)

type	material	Location		
		Ivan	dome	entrance
Groined vault	Plaster	-	✓	-

Figure 6.33: *Squinch* (author) ,reference of measure drawing(Golombek et al., 1988)

6.3.3.5.Pointed Arch

With regards to Figure 6.35 , Figure 6.37 , Figure 6.39 &Table 6.10 and and comparison with Persian pointed arch (see Figure 6.34, Figure 6.36, Figure 6.38), it was realized that type 3-2 of the pointed arch was used to cover big spaces, such as the south *ivan*, domed chamber transition system, and load bearing systems. Type 4-1 and type 6-2 of the pointed arch were applied for covering small spaces such as the *mihrab*, façade yards, and nave galleries.

Table 6.10: General analysis of pointed arch (Author-2012)

	type	**material**	**Number of center**	**Location**	
				inside	Outside
1	Type 3-2	plaster	4		Entrance
2	Type 3-2	plaster	4	Domed chamber transition system	-
3	Type 3-2	plaster	4	Domed chamber load bearing system	-
4	Type 3-2	plaster	4	-	South *Ivan*
5	Type 4-1	plaster	4	-	East &west &North *Ivan*
6	Type 4-1	plaster	4	-	Courtyard facade
7	Type 6-2	Mosaic faience	3	*mihrab*	-
8	Type 6-2	plaster	3	Nave gallery	-

Figure 6.35: Arch of south *Ivan (left)*, arch of entrance (right) (Author-2012)

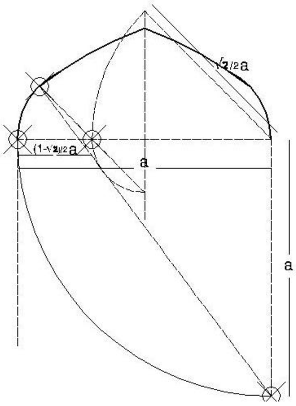


Figure 6.34: Type 4-2 of Persian pointed arch (Pirnia, 1991)

Figure 6.37: Arch of domed chamber (transition and load bearing system) (left), arch of courtyard façade (right) (Author-2012)

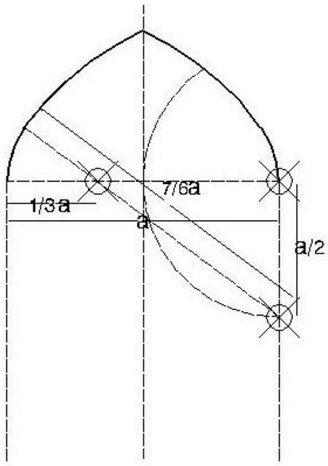


Figure 6.36: Type 4-1 of Persian pointed arch (Pirnia, 1991)

Figure 6.39: Arch of nave gallery (left), arch of *Mihrab* (right) (Author-2012)

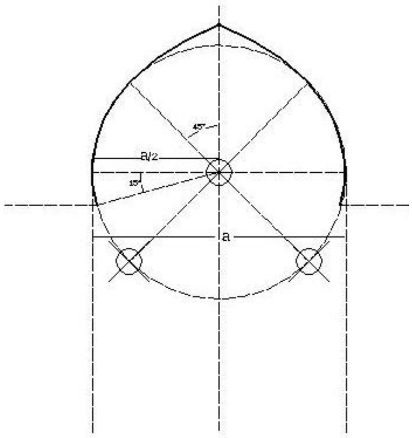


Figure 6.38: Type 6-2 of Persian pointed arch (Pirnia, 1991)

6.4.Third case study: Mosque of Torbat Jam

- ○Location: **Torbat Jam, Iran**
- ○Date: **1442-43**
- ○Building usage: Jami **mosque**

Figure 6.40: Timurid map (created by Arab Atlas)

6.4.1. History

The shrine complex of Torbat -i Jam is situated in the Khorasan province on the eastern of Persia. (Figure 6.40).it commemorated Sheikh Ahmad –I Jami , a Sufi theologian anad poet who spent most of his life in the small town of Buzanjan which was renamed Torbat –i Jam (tomb of Jam) after his death in 1141AD (Golombek et al., 1988).

The shrine complex of Torbat-i Jam has ten structures on the site that were built in eight different phases beginning in the early 13th century. Among these ten structures, six of them (refer to Figure 6.41) are more important, and were developed during three main historical periods (Illkhanid, Timurid, Safavid): 1) New Mosque (Masjid-i No),2) Dome Chamber (Gunbad) , 3) Saracha *Khanqah* and Fariwandi *Madrasa* , 4) the Old mosque (Masjid –I Atiq) , 5) Kirmani mosque,6) Madrasa of Amir Shah Malik. Timurid Amir Jalal al –din Firuzshah built the New mosque in 1442 -43 abutting the *gibla* walls of the *Saracha Khanqah* , domed chamber and Old mosque (Golombek et al., 1988).

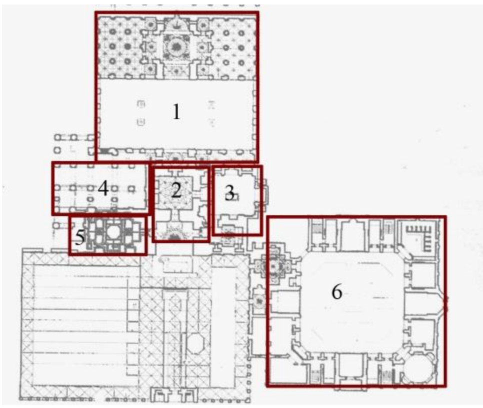


Figure 6.41: Shikh-e Ahmad jam complex(pirnia, 2001)

6.4.2. Architecture

Similar to some of the mosques in Khorasan (east of Persia), the Jami mosque of Torbat Jam was designed based on mosques with two *Ivans*; the nave gallery in the east and west site of the courtyard were added and altered in the later periods. The new mosque is a rectangular courtyard, and was originally flanked by arcades on all sides; the double-bay side arcades did not survive, and were replaced by brick walls that still stand today. The single –bay northeast has survived ; it contains a door into domed chamber, and leads into the *gibla* row of the old mosque at one end (Golombek et al., 1988).

The prayer hall that is located in the southeast of the courtyard has a cross-shaped sanctuary at its center. Its plastered interior and *mihrab* niche are ornamented simply with black lines and yellow bands. The sanctuary has eight doors leading into flanking halls (O'Kane, 1979).

6.4.3. Analysis

6.4.3.1. Ivans

Two tall *Ivans* are situated in the middle of the south and north sides are totally similar to each other but differ in width. The north *Ivan* is connected to the naves and shrine of Sheikh Aahmad Jami, while the south is only connected to the domed chamber. In contrast to the popular Timurid material, the *Ivans* were embellished by brickworks (refer to Figure 6.42, Figure 6.43 &Table 6.11).

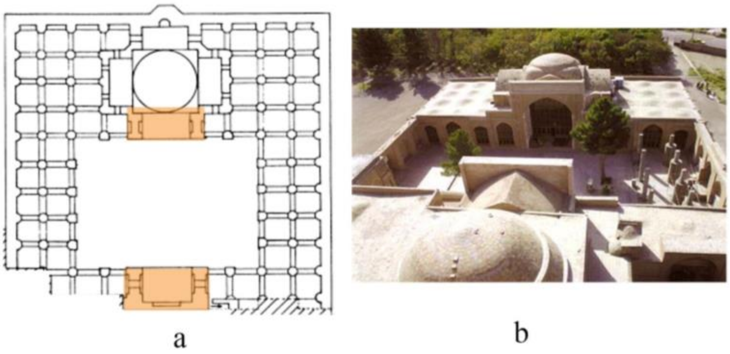


Figure 6.42: Position of *ivans* a) in pelan b) 3-D view . ref of measure drawing(Haji-ghasemi, 2005)

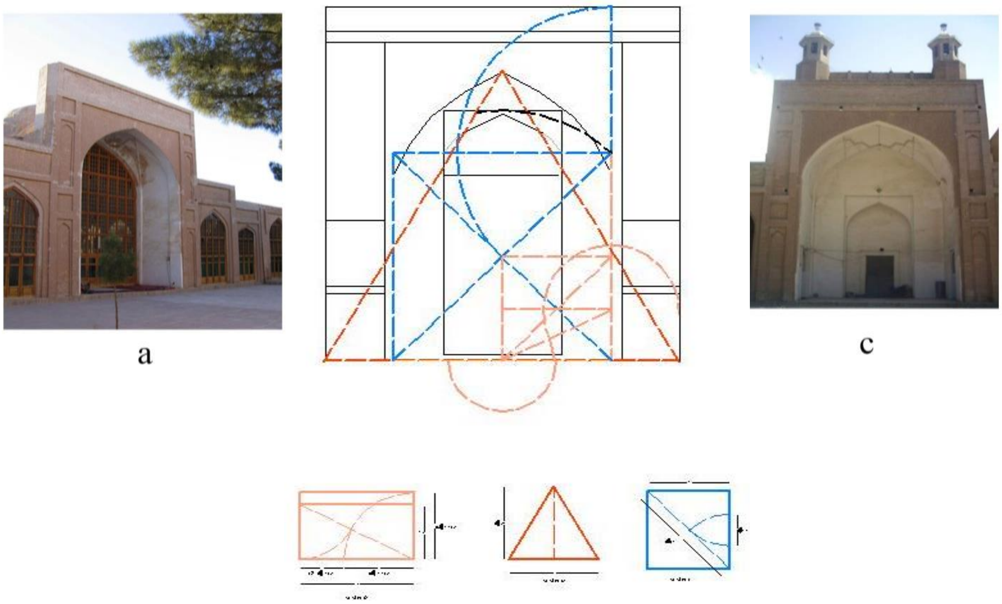


Figure 6.43: a) South *ivan* ,b) Geometrical analysis façade of south &north *Ivan* (author),c) north *Ivan* (author)

Figure 6.43 (b), Figure 6.44 & Figure 6.45 displays the geometrical analyses for both plans and façades of *ivans* that were based on Persian geometrical patterns. Among these patterns, patterns one, two, five, and eight used the façade of north and south *ivans*. In the plans of south *Ivan*, patterns three, four and five were used, but in the north *ivan*, only patterns three and nine were used in a horizontal manner.

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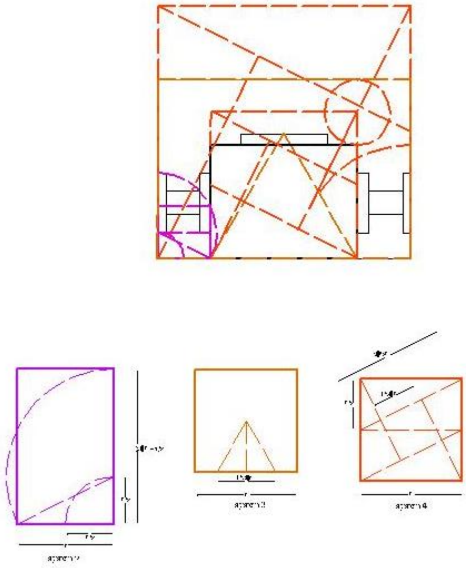


Figure 6.45: Geometrical analysis of north Ivan (Author-2012)

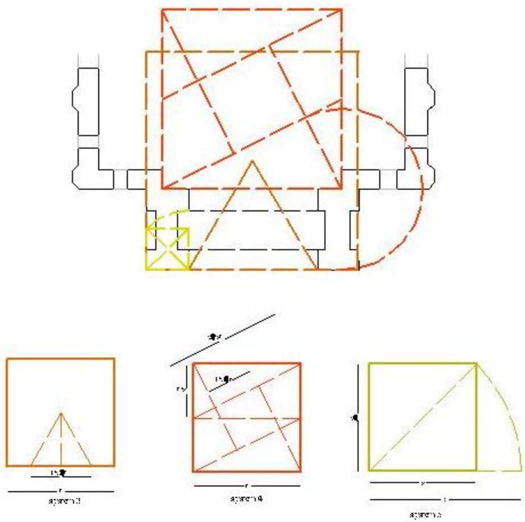


Figure 6.44: Geometrical analysis plan of south &north *Ivan*(Author-2012)

Table 6.11: General analsis of Ivans (Author-2012)

Ivan	shape	dimension			Elements of *Ivan "screen"*											material	relation		Location of the facade			Geometrical patterns	
		L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	Domed chamber	front	back	flat	plan	Façade
South *Ivan*	rectangular	12	8.5	12	✓	✓	✓	✓				✓				Brick		✓			✓	3,4,5	1,2,5,8
North *Ivan*		12	9.5	12	✓	✓	✓	✓				✓					✓				✓	3,5,9	1,2,5,8

element of *Ivan* screen
1.inscription frieze
2.spandrel
3.band
4.plinth
5.minaret
6.scroll
7.blind arcade
8.open arcade
9.muqarnas
10.squnch net
11.parapet

6.4.3.2. Domed Chamber

Table 6.12: General analysis of domed chamber (Author-2012)

Domed chamber	shape	dimension			Elements of internal facade							relation			opening	material	Geometrical pattern	
					Load bearing		Transition section										plan	Façade
		L	W	H	1	2	1	2	3	4	5	*Ivan*	nave	*Mihrab*				
	Cross shape	10	10	13.5	1	7			✓	✓		✓	✓	✓	2	plaster	2,4,8	1,3,4

load bearing system
1.blind arcade
2.open arcade

transition system
1.squinch
2.pendative
3.recumbent arch
4.arch-net (*squinch*-net)
5.muqarnas

The prayer hall is situated in the southeast of the courtyard. It is ten bays deep and four bays wide, with a cross-shaped sanctuary at its center. A tall portal centered on the courtyard arcade opens into the sanctuary. The domed chamber was entirely covered by plaster. In addition, four windows are located at the transition level, and the sanctuary has eight doors leading into the flanking halls (Table 6.12, Figure 6.46 & Figure 6.47).

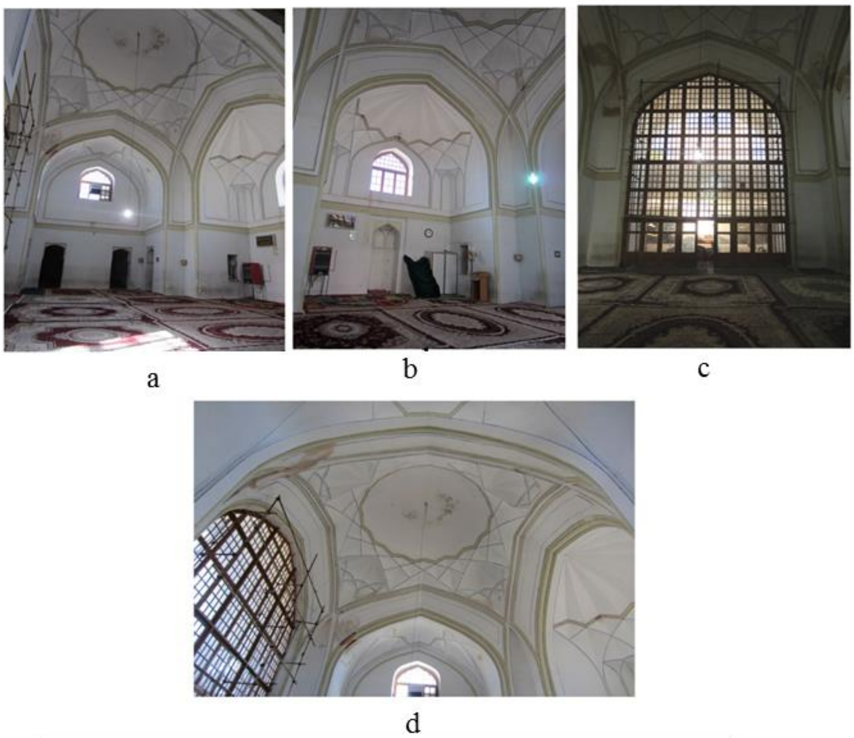


Figure 6.46: a) General view of domed chamber, b) *Mihrab*, c) View to *Ivan*, d) Ceiling (Author-2012)

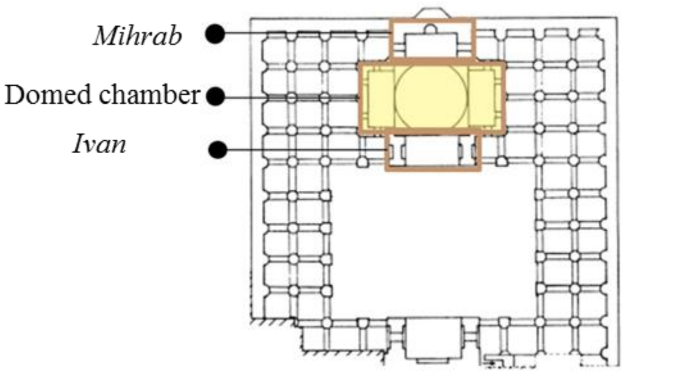


Figure 6.47: Combination domed chamber, *Ivan, Mirab* ref of measure drawing (Haji-ghasemi, 2005)

Figure 6.48 & Figure 6.49 display the geometrical analyses for both plans and façades of domed chamber based on Persian geometrical patterns. Between these patterns, patterns two, four, and eight were used by the façade, while patterns one, three, and four were applied in the plan.

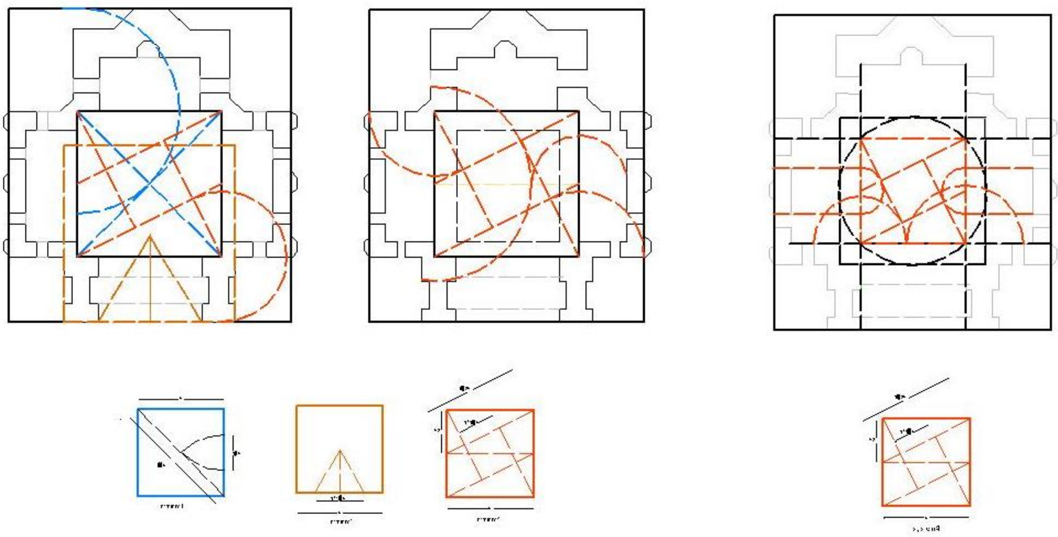


Figure 6.48: Geometrical analysis of combination domed chamber, *Ivan, Mihrab* (Author-2012)

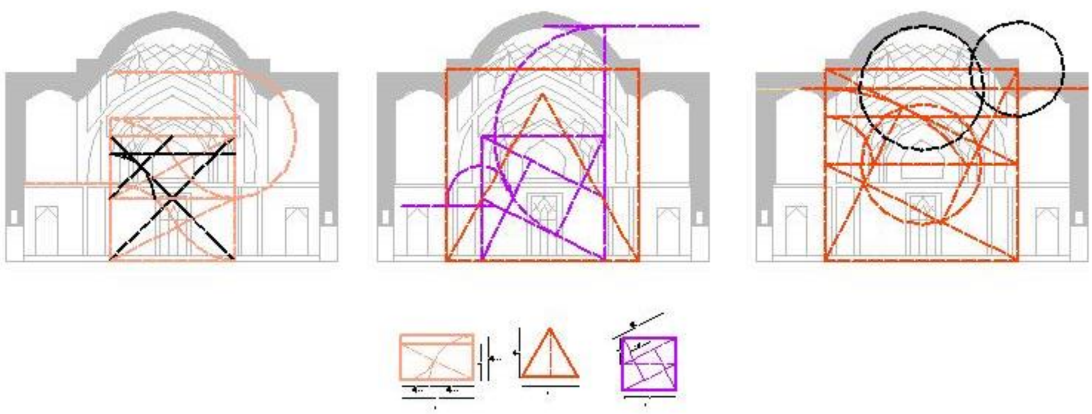


Figure 6.49: Geometrical analysis section of domed chamber (Author-2012)

6.4.3.3. Squinch

Instead of *squinch*, a recumbent arch was used in the mosque of Torbat Jam. This device is abutted by semi-domes extended down to fill the space between the arches in the shape of a kite. The inside of the recumbent arches are filled with *squinch* net (arch-net) (Figure 6.50)

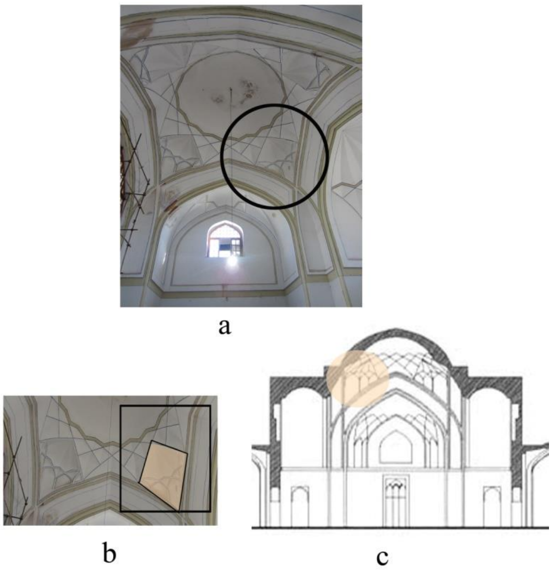


Figure 6.50: a & b) Recumbent of dome, c) General view (Author-2012)

6.4.3.5. Pointed Arch

With regards to Figure 6.51, 6.55, 6.56 and Table 6.13, there types of Persian pointed arch can be found in this mosque: type 3-1 (Figure) and type 3-2 (Figure) for big spaces such as the north and south *ivans* and the domed chamber, and Type 6-2 for the *mihrab*, as it is a small space.

Figure 0.1: Arch of south *Ivan* & courtyard(left), arch of, north *Ivan (*right) (Author-2012)

Table 6.13: General analysis of pointed arch (Author-2012)

	type	material	Number of center	Location	
				inside	Outside
1	Type 3-2	Brick	3	-	South *Ivan*
2	Type 3-2	Brick	3	-	North *Ivan*
3	Type3-2	Brick	3	-	Façade yard
4	Type 3-1	plaster	4	Domed chamber	-
5	Type 6-1	plaster	3	*Mihrab*	-

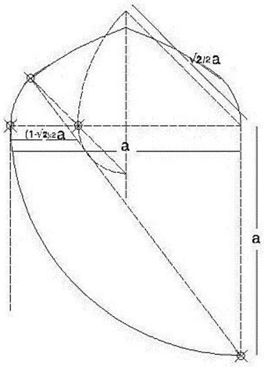


Figure 6.54: Type 3-2 of Persian pointed arch(Pirnia, 1991)

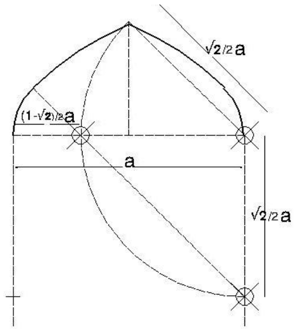


Figure 6.53: Type 3-1of Persian pointed arch (Pirnia, 1991)

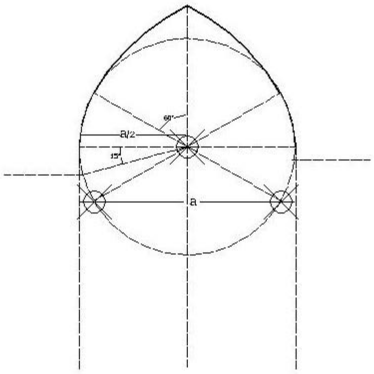


Figure 6.52: Type 6-1of persain pointed arch (Pirnia, 1991)

Figure 6.55: Arch of *Mihrab* (Author-2012)

Figure 6.56: Arch of domed chamber's vault & *squinch* net (Author-2012)

6.5. Fourth case study: Shah Mosque (Emam mosque)

- Location: **Isfahan, Iran**
- Date: **1602**
- Building usage: ***Madrasa*, Mosque**

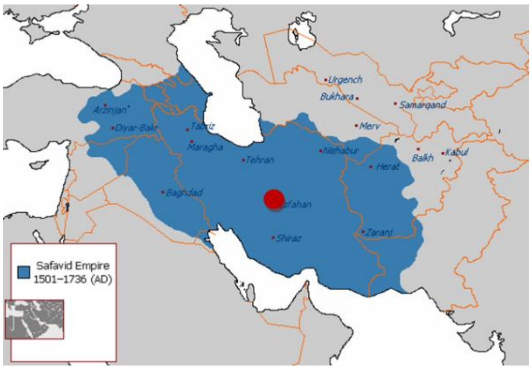


Figure 6.57: Safavid empire map (created by Arab Atlas)

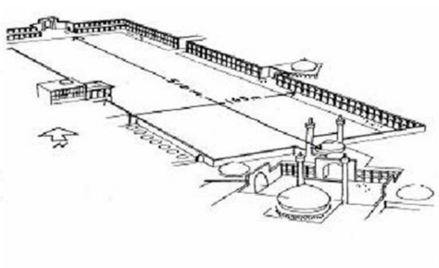
6.5.1. History

The Shah mosque was built on the south side of Naghe Jahan‘s square in Isfahan (Figure 6.57), while this royal square was built by Shah Abbas, and competed in 1602. The Shah mosque was largest architectural monument in Shah Abbas era. The mosque‘s monumental portal *Ivan* is situated accurately opposite the portal *Ivan* of the northern arcade of the square. Badi' al –Zaman Tuni was responsible for the building‘s plans and arrangement of site, and Ali Akbar Isfahani was engineer. (Haji-ghasemi, 2005).

6.5.2. Architecture

The 17th century was not the supreme period of Persian art, and in various details, the Masjid -i-Shah is inferior to its model, the mosque of Gohar Shad. The enamel tiles that cover the whole interior of the Masjid-i-Shah are inferior to the mosaic faience of the preceding centuries, or even to its own outer portal; and it can be surmised that in design or execution, it was no more than a routine interest. However, in the nobility of form, in serene strength and repose, in powerful affirmation and valid expression of the spirit of Islam, Masjid -i-Shah represents the culmination of thousands of years of mosque building in Persia. Its externalities is enriched by galleries, recesses, masses of gleaming stalactites, and long bands of brilliant white inscriptions (Pope, 1965) .

Following the Persian traditional mosque plans, the shah mosque has a court (50 by 67 meters) enclosed by a two–story arcade on four sides with four *ivans*, one at the center of each side, and a domed sanctuary behind the southwest *ivan*, oriented towards *gibla*. Nonetheless, the plan of mosque shows an intersecting variation : behind each lateral *ivan* (in the northwest and southwest) is a domed chamber (pirnia, 2001)(refer to Figure 6.58).



a

b

Figure 6.58 :a) Naghe Jahan square , general view of Shah mosque (pirnia, 2001)

6.5.3. Analysis

6.5.3.1. Ivans

The Shah mosque was known as a congressional mosque, which makes the four *Ivans* suitable in this case. All *Ivans* were associated to adjacent space (naves, domed chamber, corridors) by vaulted tunnels. The four *Ivans* of the Shah Mosque were entirely decorated by polychrome (Seven colour tile) with the colors dark blue, white, green, and above high continuous marble dado were seven colored-tiles, which were the most used materials for construction during the Safavid era. South *Ivan* of the Shah Mosque used minarets that extended from the top of the back façade (see Table 6.14, Figure 6.59 , Figure 6.60 , Figure 6.61, & Figure 6.62).

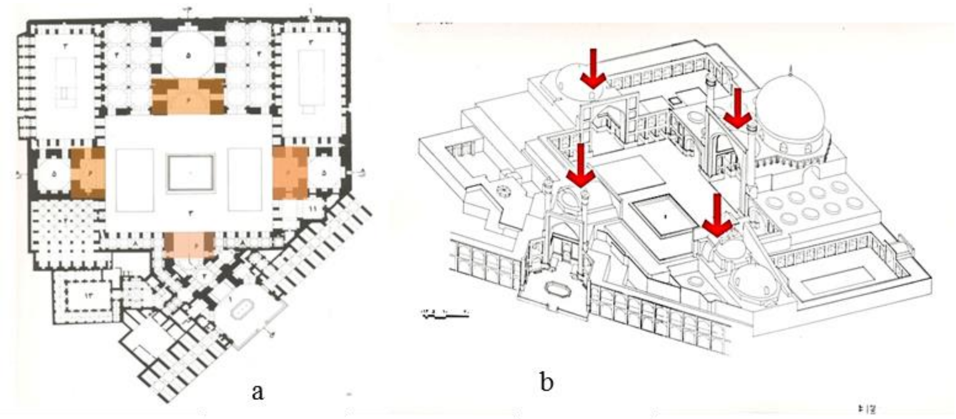


Figure 6.59: Position of Ivans a) in pelan b) 3-D view . ref of measure drawing(Haji-ghasemi, 2005)

Figure 6.61: Detail of south *Ivan* ceiling (Author-2012)

Figure 6.62: South *Ivan* (Author-2012)

Figure 6.60: North *Ivan* (similar west & east *Ivan*s (Author-2012)

Figure 6.63, Figure 6.64, Figure 6.65 & Figure 6.66 display the geometrical analyses for both plans and façade of *ivans* based on Persian geometrical patterns. Among these patterns for south *ivan*, patterns one, two, five, eight and nine were used in the façade, while patterns one, three, and four can be seen in the plan of *qibla ivan* like the other *ivans*. In contrast to the similarity in the plan of all *ivans*, only patterns one, five and eight were applied vertically in the other *ivans*.

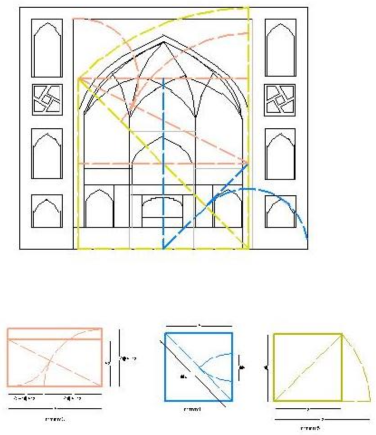


Figure 6.63: Geometrical analysis façade of east & west & north *Ivan*s (Author-2012)

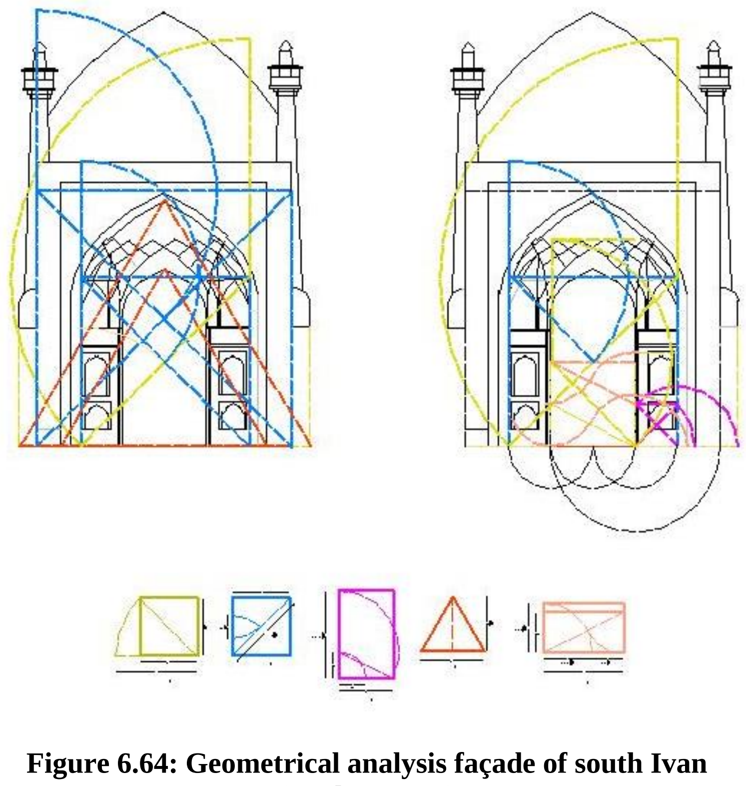


Figure 6.64: Geometrical analysis façade of south Ivan (Author-2012)

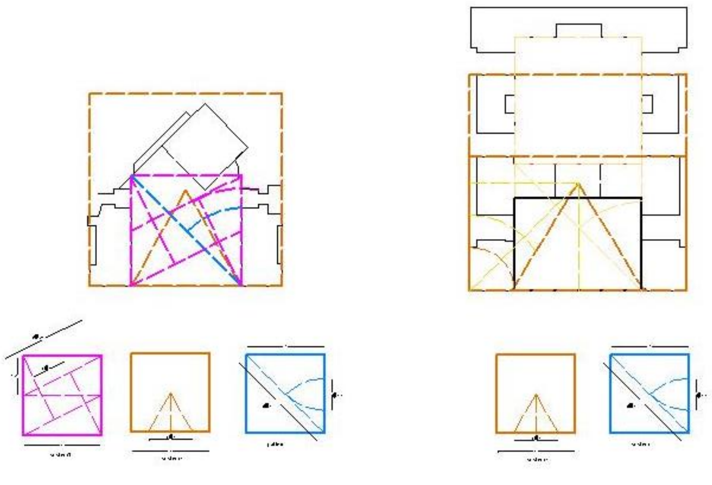


Figure 6.65: Geometrical analysis: the plan of north *Ivan* (left), plan of east & west *Ivans* (right) (Author-2012)

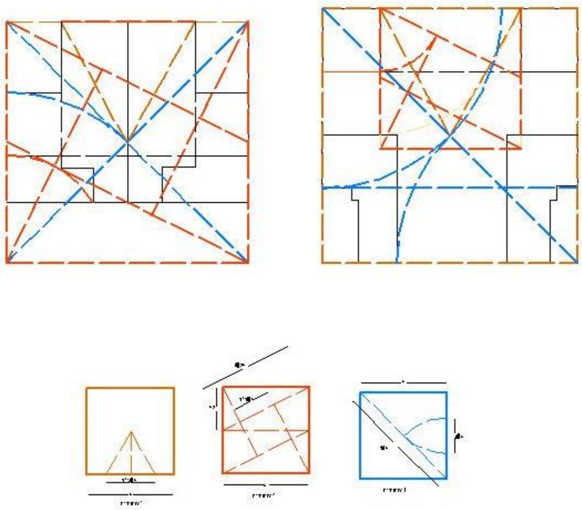


Figure 6.66: Geometrical analysis of south *Ivan* (Author-2012)

Table 6.14: General analysis of *Ivans (*Author-2012)

Ivan	shape	dimension			Elements of *Ivan "screen"*											material	relation		Location of the facade			Geometrical patterns	
		L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	Domed chamber	front	back	flat	plan	Façade
South *Ivan*	rectangular	34	17	34		✓	✓	✓	✓		✓	✓		✓		seven color+ Mosaic faience		✓			✓	1,3,4	1,2,5,8
North *Ivan*		25.5	15	20.5		✓	✓	✓			✓	✓		✓			✓				✓	1,3,4	1,5,8
East *Ivan*		29	17.5	23		✓	✓	✓			✓	✓		✓			✓				✓	1,3,4	1,5,8
West *Ivan*		29	17.5	23		✓	✓	✓			✓	✓		✓			✓				✓	1,3,4	1,5,8

element of *Ivan* screen

1.inscription frieze
2.spandrel
3.band
4.plinth
5.minaret
6.scroll
7.blind arcade
8.open arcade
9.muqarnas
10.squnch net
11.parapet

6.5.3.2. Domed Chamber

Table 6.15: General analysis of domed chamber (Author-2012)

Domed chamber	shape	dimension			Elements of internal facade							relation			opening	material	Geometrical pattern	
					Load bearing		Transition section										plan	Façade
		L	W	H	1	2	1	2	3	4	5	*Ivan*	nave	*Mihrab*				
	Square	25	25	38	25	11	✓					✓	✓	✓	2	Seven color	1,3,4,8	1,2,5,8,9

load bearing system

1.blind arcade
2.open arcade

transition system

1.squinch
2.pendative
3.recumbent arch
4.arch-net (*squinch*-net)
5.muqarnas

The square pattern is adapted into the Shah mosque. This space was connected to the naves by three tunnels at each side. The *Mihrab* and entrance and central tunnels are of the same lengths and heights. The interior of the dome is ornamented with sunburst at the apex from which the tiers of the arabesque descends. The domed chamber is decorated with seven-color tiles work of concentric medallions in floral motifs. The mosque has two big windows at the transition level and four apertures in the internal shell zone (see Table 6.15, Figure 6.67 & Figure 6.68).

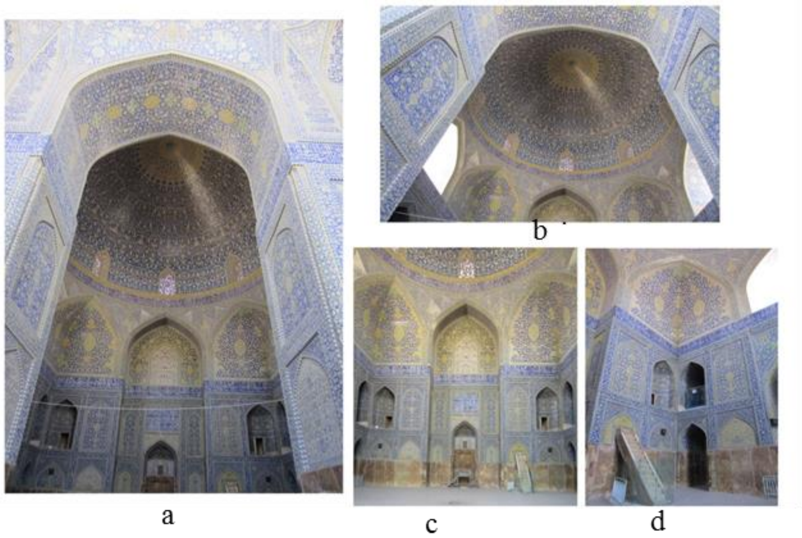


Figure 6.68: a) Domed chamber, b) Ceiling of domed chamber, c) *Mihrab*, d) Corner of load bearing section (Author-2012)

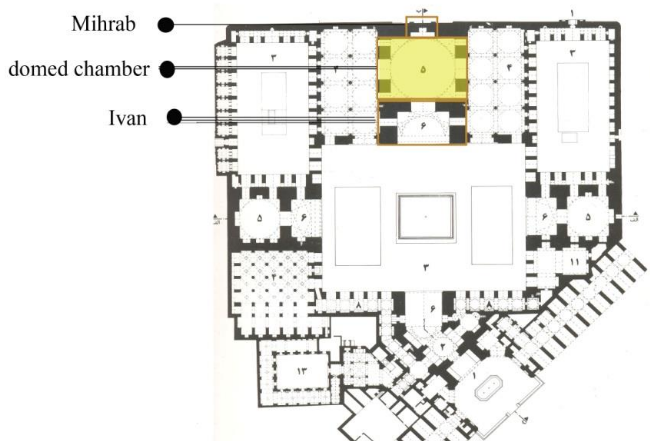


Figure 6.67: Combination domed chamber, *Ivan, Mirab,* ref of measure drawing (Haji-ghasemi, 2005)

Figure 6.69 & Figure 6.70 display the geometrical analyses for both plans and façades of *ivans* based on Persian geometrical patterns. Among these patterns, patterns one, three, four, and eight were used in the plan, while patterns two, five, eight and nine were applied to the façade.

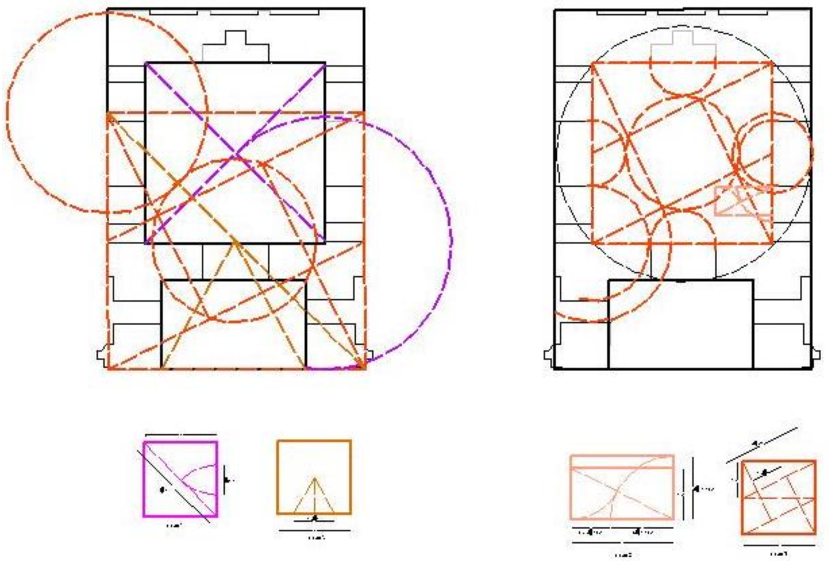


Figure 6.69: Geometrical analysis: a) combination domed chamber, *Ivan, Mihrab, b*) Domed camber(Author-2012)

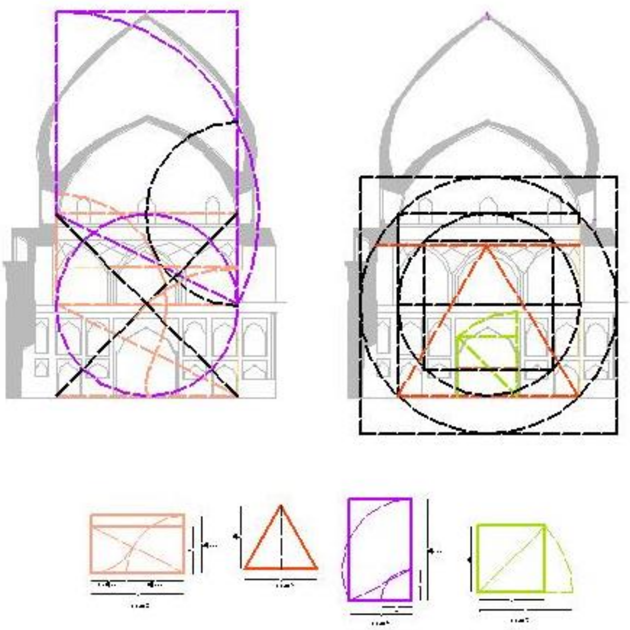


Figure 6.70: Geometrical analysis section of domed chamber (Author-2012)

6.5.3.3. Double Dome

The dome of the sanctuary has vast scale (25 m across by 52 m high), and encompasses of two shells; the bulbous dome being 14 m higher than interior dome. On the exterior the bulbous dome is covered with a spiraling arabesque on the light blue background. The dome rises on a high drum and a sixteen-sided transitional zone (Table 6.16, Figure 6.71, Figure 6.72 & Figure 6.73).

Table 6.16: General analysis of double dome (Author-2012)

type	**Supporting system**	**Transition tier**	**C****	**Type of internal shell**		**Type of external shell**		**drum**	**material**	
				type	H*	type	H*	type	outer	inner
Discontinuous double dome	Square with bearing wall	squinch	76	Semi circular	37	Bulbous	52	Cylinder	Seven color mosaic	

*Height from floor to end of dome C** circumference

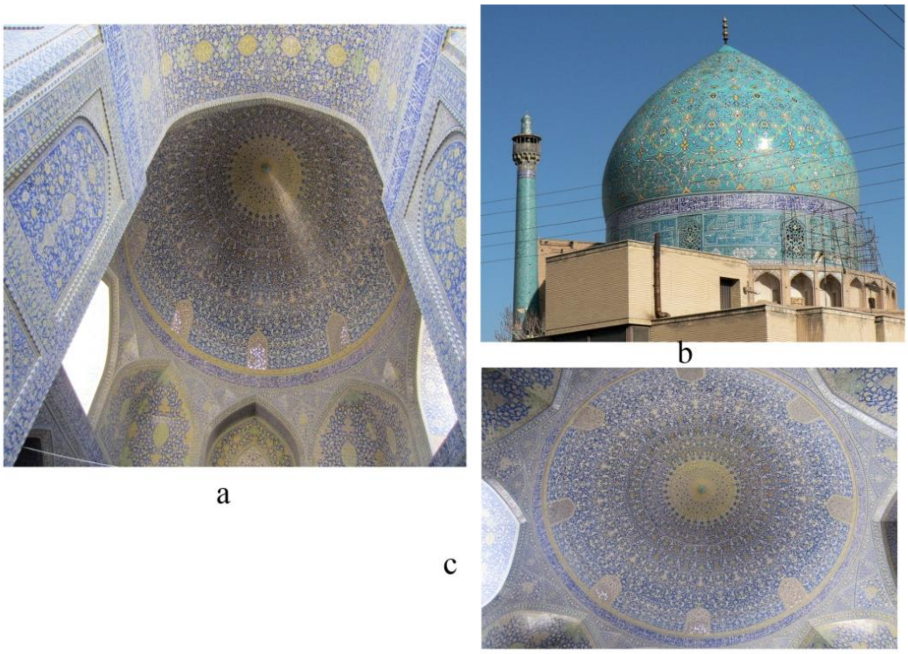


Figure 6.71: Double dome :b) Internal ceiling, a & c) External dome (Author-2012)

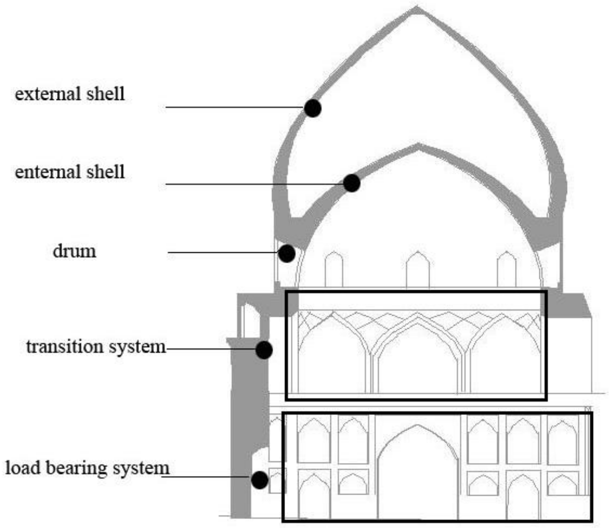


Figure 6.72: Transversal section , ref of measure drawing (Haji-ghasemi, 2005)

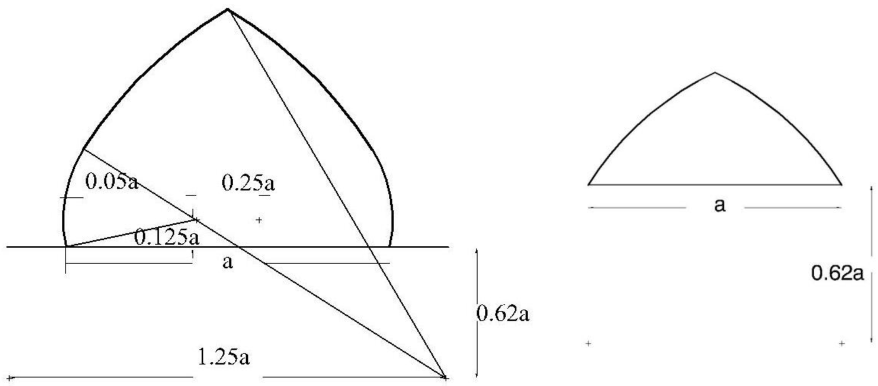


Figure 6.73 : Geometrical analysis of: external shell (left), Internal shell (right) (Author-2012)

6.5.3.4. Squinch

The groined vaults, blind arches and arch windows, and small-scale arches above main arches formed the bold unit of transition system that was separated from supporting system by the inscription band (see Figure 6.74, &Table 6.17).

Table 6.17: General analysis of *squinch* (Author-2012)

type	material	Location		
		Ivan	dome	entrance
Groined vaults	Seven color mosaic		✓	✓

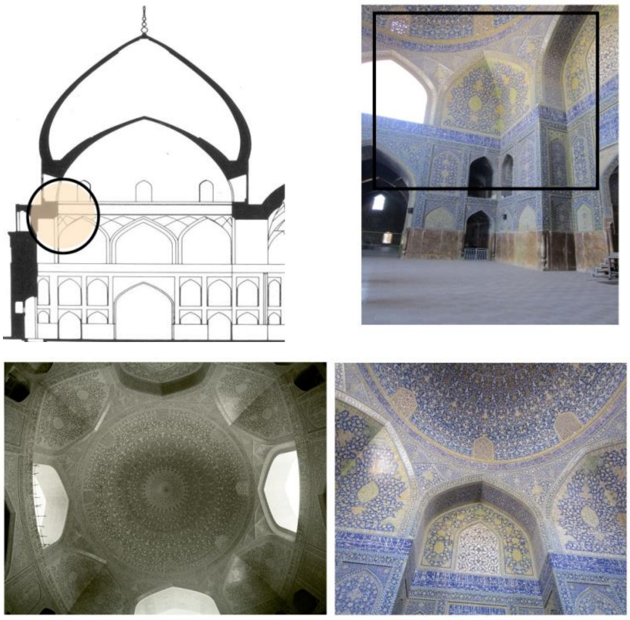


Figure 6.74: *Squinch* of dome(author), Ref of measure drawing(Haji-ghasemi, 2005)

6.5.3.5. Pointed Arch

Based on Table 6.18, Figure 6.75, Figure 6.76 & Figure 6.78 and comparison with Persian pointed arch in Figure , type 3-1 was used for all spaces with different heights and lengths.

Table 6.18: General analysis of pointed arch (Author-2012)

	type	material	Number of center	Location	
				inside	Outside
1	Type 3-1	Seven color mosaic	4	Transition section of Domed chamber	-
2	Type 3-1	Seven color mosaic	4	Load bearing system of Domed chamber	-
3	Type 3-1	Seven color mosaic	4	Nave	
4	Type 3-1	Seven color mosaic	4	Corridor of entrance	
5	Type 3-1	Seven color mosaic	4	-	North *Ivan*
6	Type 3-1	Seven color mosaic	4	-	West & east *Ivan*
7	Type 3-1	Seven color mosaic	4	-	couryard
8	Type 3-1	Seven color mosaic	4	-	South *Ivan*
9	Type 3-1	Mosaic faience	4	-	Entrance

Figure 6.75 : Arch of Corridor entrance (left), Arch of transition and load bearing system (Center, right) (Author-2012)

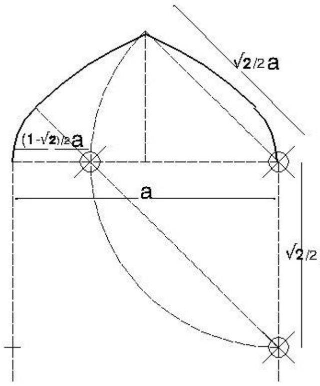


Figure 6.77: Type 3-1 of Persian pointed arch (Pirnia, 1991)

Figure 6.76: Arch north & east &west and courtyard (Author-2012)

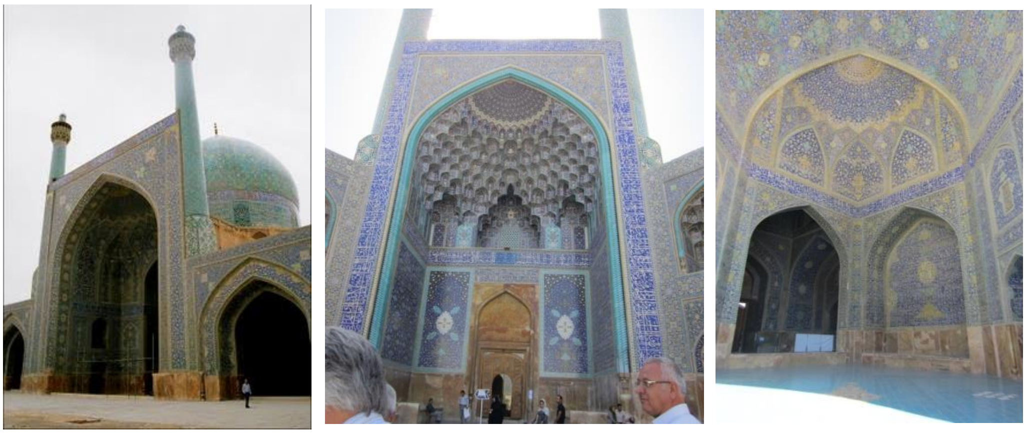


Figure 6.78: Arch of: south Ivan (left), entrance (center), north Ivan (right) (Author-2012)

6.6.Fifth case study: Fatehpur Sikri Jami mosque

- Location: **Uttar Pradesh State, India**
- Date: **1571-85**
- Building usage: **Jami Mosque**

Figure 6.79 Mughal empire map ("www.wikimedia.org,")

6.6.1.History

The Jami mosque of Fatehpur Sikri, located in Agra (Figure 6.79), is the sacred complex of the fortified imperial city built by the Mughal Emperor Jalal'ud-Din Muhammad Akbar (reg.1556-1605 AD), son of Humayun, and grandson of Babur. The mosque not only ranks among the largest of the class in the country, but also provides a most typical and finished example there is of the Mughal style, and it is the first of the "giant open mosques" now typical of Mughal cities. Like the imperial residence, this imperial mosque is a showpiece of the great Akbari synthesis (Bunce, 2008; Desai, 1971; Koch, 1991b).

6.6.2.Architecture

The plan of Jami mosque of Fatehpur Sikri is strongly reminiscent of Timurid origins, but its composition is new and its detail Indian. It may indeed be suggested that Akbar 's own ideas about the reconciliation of the Muslim and Indian religion in a single faith find their most vivid expression in this architecture (Kuban, 1985).

The mosque consists of a rectangular court with an arcade fronting individual and regularly spaced spaces around its four interior surfaces. In the courtyard of the mosque, there are two tombs: Salim Chishti and Islam Khan. The mosque had originally three lofty entrance halls, of which the majestic Buland Darwaza replaced the one on the south a little later. Certainly one of the most impressive entrances or gateways in the history of world architecture is to be seen in the magnificence and colossal Boland Darwaza(Bunce, 2008; Desai, 1971; Fergusson, 1910; Kuban, 1985; Stierlin & Stierlin, 2002).

The mosque is enclosed in the west side by the prayer hall where three domed chambers are embedded; a central one proceeded by a *pishtaq*. The interior of the sanctuary was divided at the central nave and side compartments that are sort of open chambers connected to each other by pillared aisles. The system of supporting the roof is made up of skillfully employed beams and arches. The area of central elements is covered by a dome set within five-bay deep. Two smaller domes are seen flanking this central form. The triple-domed haram become a feature of later Mughal mosques. However, here, the domes are massive and rather stogy in form – not as elegant and graceful as those found in the Jami mosque of Delhi and Lahore (Bunce, 2008; Desai, 1971; Koch, 1991b).

6.6.3.Analysis

6.6.3.1.Ivans

As per the mosques in other countries, Mughal mosques can be accessed from two or three sides, and were designed based on multiple gateways. Each gateway is connected to an *Ivan.* In the Fatehpur Sikri mosque, three *ivans* can be seen in the east, west, and the south. The north *Ivan* is converted to the entrance of the internal tomb, which disqualifies it as an *Ivan.* The southern and eastern ones merges with the gateways and the size and horizontal form follow the gateways. The east *Ivan* is bigger than the others are because it is adjacent to the majestic *Buland Darwaza* (lofty gate). The components of each *ivans* are similar; these comprised of a high central recessed arch set into a rectangular frame and crowned by a parapet with *chattris* (domed pavilions) (see Figure 6.80 &Table 6.19).

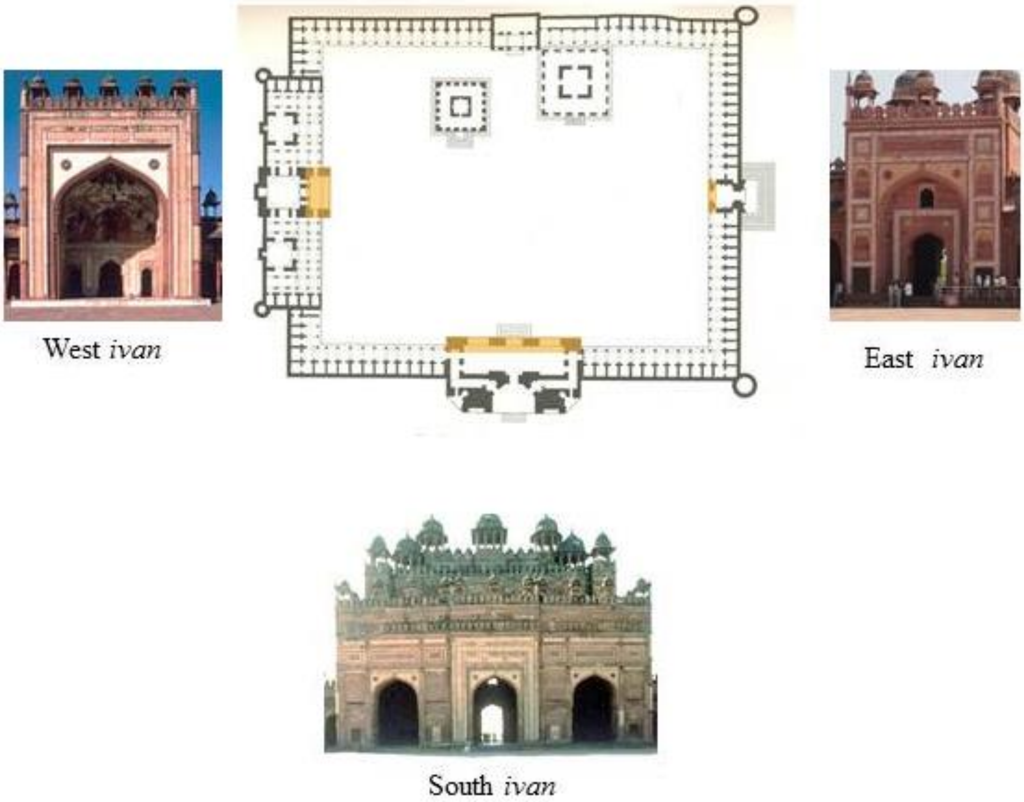


Figure 6.80: Position of *ivans* in pelan with pictures of each *ivans* ref of measure drawing:(Bunce, 2008), ref of pictures (Author-2012)

Regarding Figure 6.81, Figure 6.82, Figure 6.83, Figure 6.84 , Figure 6.85& Figure 6.86 , they all show the geometrical analyses for both the plans and façade of *ivans* based on Persian geometrical patterns. Patterns two and four were used in the facade of all *ivans* , but pattern five was only used for the west and south *ivans* , and pattern one only for the south *ivan*. In the plan, the east and west *ivan* followed similar manner in using patterns three and four, on top of patterns three and five being present in the plan of the south *ivan*.

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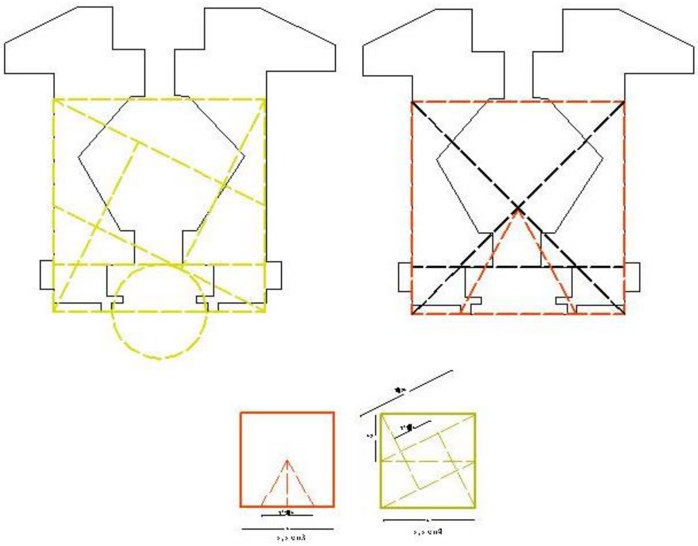


Figure 6.82: Geometrical analysis of west *Ivan* (Author-2012)

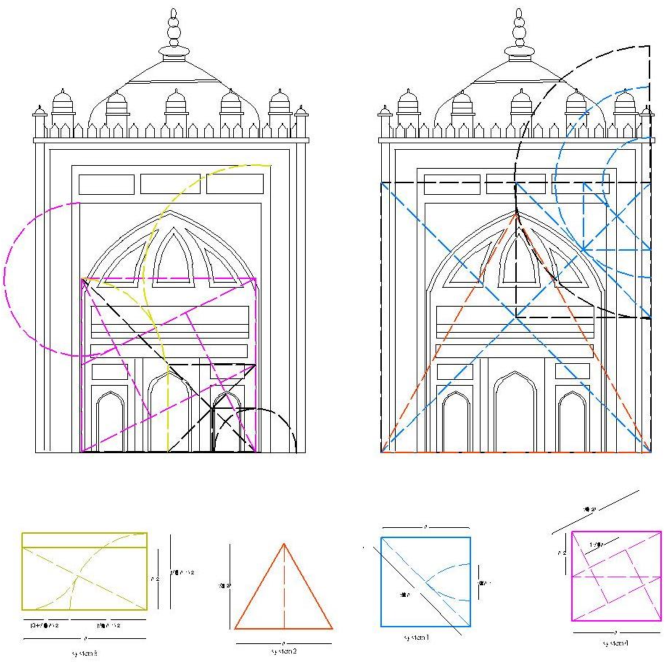


Figure 6.81: Geometrical analysis of façades of west *ivan* (Author-2012)

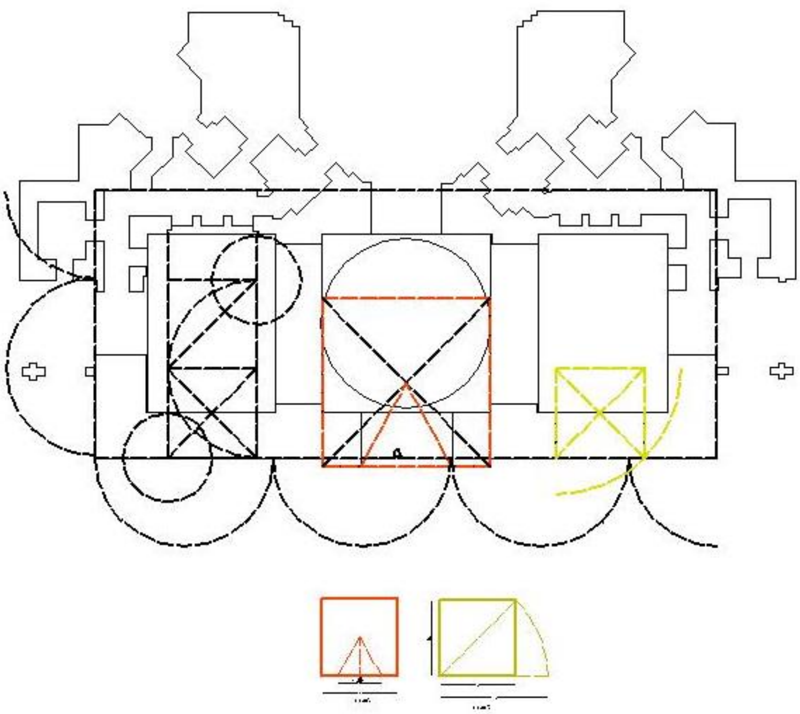


Figure 6.84: Geometrical analysis   south *ivan* (Author-2012)

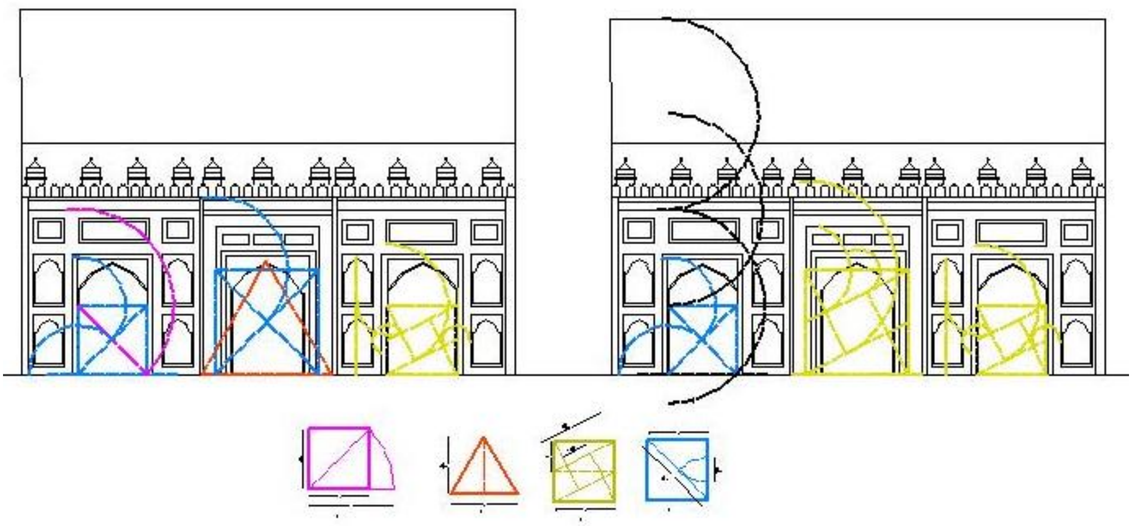


Figure 6.83: Geometrical analysis façade of south *ivan* (Author-2012)

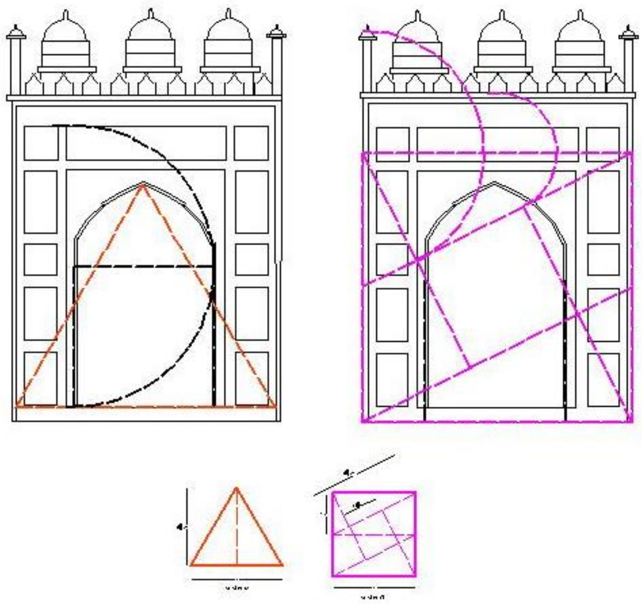


Figure 6, 86: Geometrical analysis façade of east *ivan* (Author-2012)

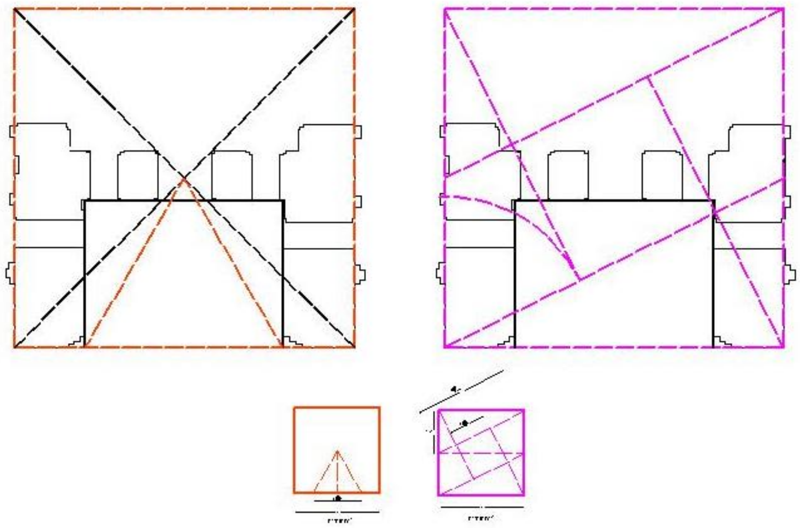


Figure 6.85: Geometrical analysis of east *ivan* (Author-2012)

Table 6.19: General analsis of Ivans (Author-2012)

Ivan	shape	dimension			Elements of *Ivan “screen”*											material	relation		Location of the facade			Geometrical patterns	
		L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	Domed chamber	front	back	flat	plan	Façade
South *Ivan*	rectangular	40	13.5	17.5	✓	✓	✓		*		✓	✓			✓	Sand stone	-	-	✓			3,5	1,3,4,5
East *Ivan*		10.5	2.3	16.5	✓	✓	✓		*		✓				✓		-	-			✓	3,4	2,4
West *Ivan*		18	8	24	✓	✓	✓		*		✓	✓		✓	✓		✓	✓	✓			3,4	2,4,5

*Mini minarets

element of *Ivan* screen

1.inscription frieze
2.spandrel
3.band
4.plinth
5.minaret
6.scroll
7.blind arcade
8.open arcade
9.muqarnas
10.squnch net
11.parapet

6.6.3.2. Domed Chamber

Table 6.20: General analysis of domed chamber (Author-2012)

Domed chamber	shape	dimension			Elements of internal facade							relation			opening	material	Geometrical pattern	
					Load bearing		Transition section										plan	Façade
		L	W	H	1	2	1	2	3	4	5	*Ivan*	nave	*Mihrab*				
	Square	12.5	12.5	21.5	3	9		✓				✓	✓	✓	4	plaster	3,4	5,8

load bearing system

1.blind arcade
2.open arcade

transition system

1.squinch
2.pendative
3.recumbent arch
4.arch-net (*squinch*-net)
5.muqarnas

The main prayer hall is located along the western side of the courtyard, while the square domed chamber was located in the center, and topped by a single dome supported on *squinches*. It is surrounded by three open arches of the southern and northern sanctuaries, and the west *ivan*. In each side, the central open arches are higher and bigger. The *mihrab*, opposite of the west *ivan*, is ornamented with inlaid stones and glazed tiles, and is flanked on either side by smaller *mihrab* niches (refer to Table 6.20, Figure 6.88 & Figure 6.87).

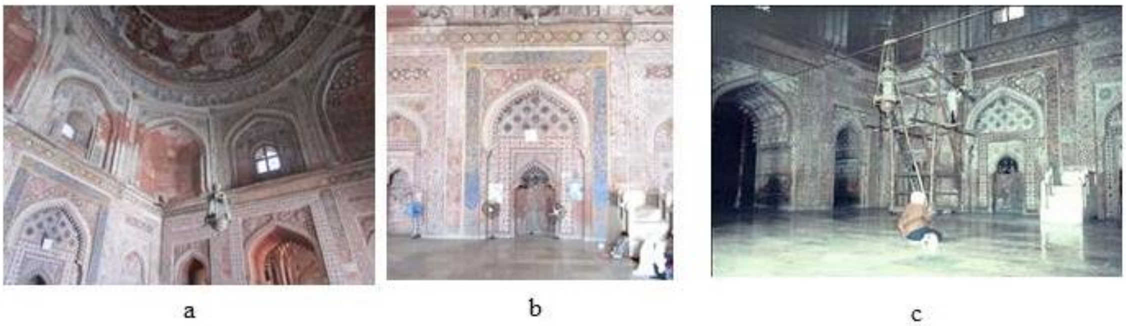


Figure 6.88: a) Transition system of domed chamber, b) *Mihrab*, c) Open arcade of load bearing section (Author-2012)

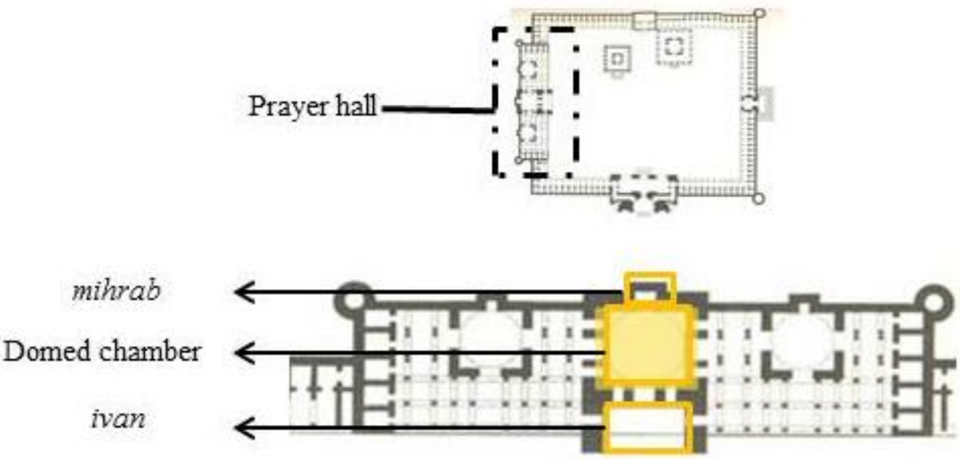
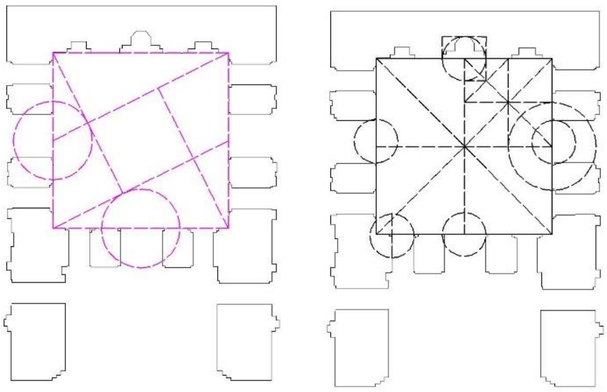
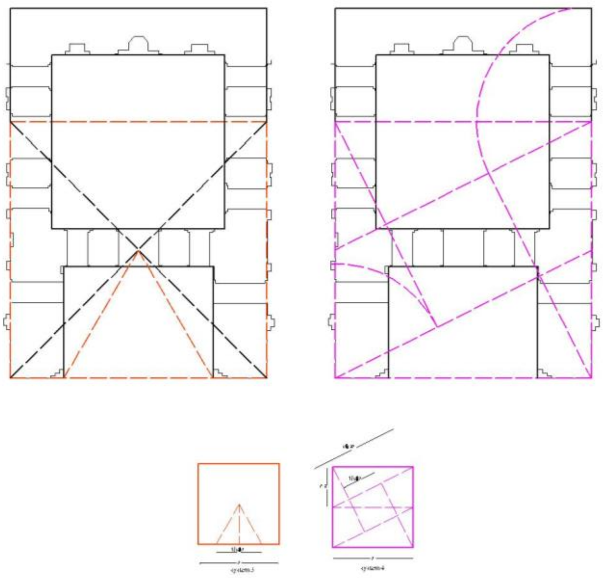


Figure 6.87: Combination domed chamber, *Ivan, mirab* ref of measure drawing(Bunce, 2008)

Figure 6.89, Figure 6.90 displays the geometrical analyses for both plan and façade of domed chamber based on Persian geometrical patterns. Patterns three and four were used in a horizontal manner, while patterns five and eight were applied in a vertical manner.



a



b

Figure 6.89: Geometrical analysis of
a) Geometrical analysis of domed chamber
b) Combination domed chamber, *Ivan*, *Mihrab* (Author-2012)

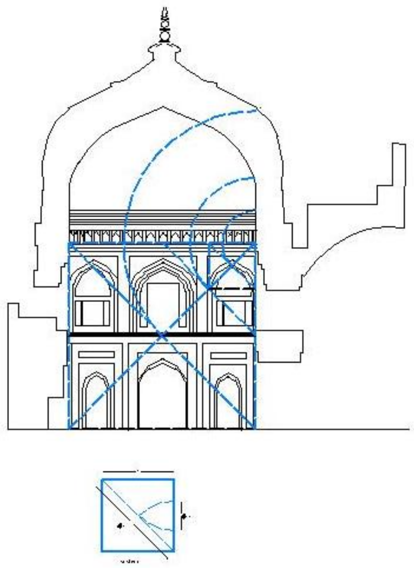


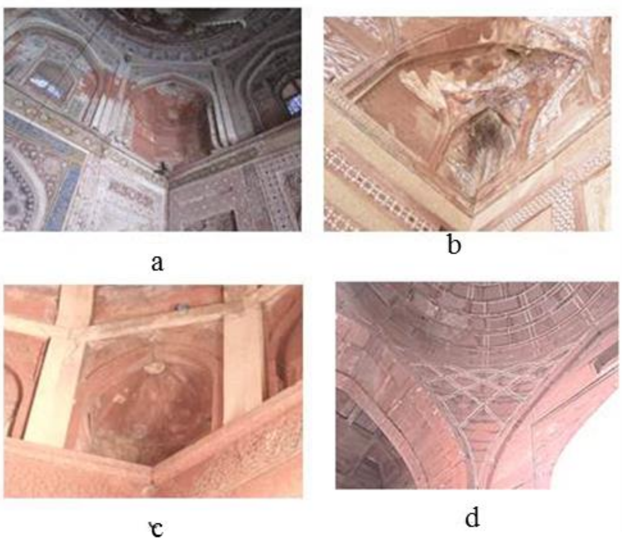
Figure 6.90:Geometrical analysis the vertical elemnsts of domed chamber (Author-2012)

6.6.3.3.3Squinch

In the Fatepur Sikri mosque, different types of *squinchs* were utilized; the simplest type can be found in the internal main entrance (Boland Darwaza), composed of a beam resting on the corners. The beam was concealed by an arch-net (*squinch* -net) as a revetment. In other spaces of the mosque, the more famous and widespread type of *squinch* (groined vaults) were applied to the transition section of the domed chamber; this non-functional element was elaborated by an arch-net (see Figure 6.91, Figure 6.92 &Table 6.21).

Table 6.21: General analysis of *squinchs* (Author-2012)

type	material	Location		
		Ivan	Domed camber	entrance
Groined vaults with revetment of arch-net	Red sand stone	✓west		
A beam across the corner with revetment of arch-net	Red sand stone			✓south
Groined vaults	Red sand stone			✓east
Groined vaults	Red sand stone &mosaic faience		✓	



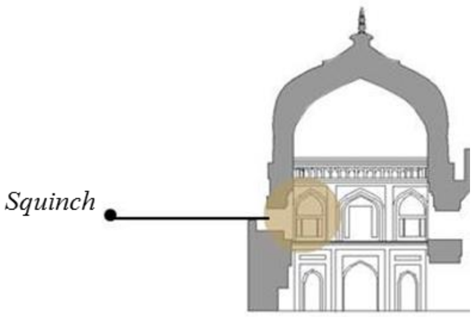


Figure 6.92: *Squinch* net of dome: a) domed chamber, b) west *Ivan*, c) east entrance, d) south entrance (Author-2012)

Figure 6.91: *Squinch* in domed chamber , ref of measure drawing (Smith, 1985)

6.6.3.4. Pointed Arch

Figure 6.95, Figure 6.96, Figure 6.97, Figure 6.98 &Table 6.22 concerns and compare Persian pointed arches (refer to Figure 6.93, Figure 6.94); the former type (3-1) was applied in most big spaces (*ivans*, south, and east entrances) and also transitional systems of the domed chamber. The latter type (3-2) can be found in main vault of some entrances, *mihrab*, and prayer halls. These two types belong to a category that normally covers big spaces.

Table 6.22: General analysis of pointed arch (Author-2012)

	type	**material**	**Number of center**	**Location**	
				inside	Outside
1	Type 3-1	sand stone	4	-	West *ivan*
2	Type 3-1	sand stone	4	-	South ivan
3	Type3-1	sand stone	4	-	North &east ivan
4	Type 3-1	sand stone	4		courtyard
5	Type 3-1	sand stone	4		South &east entrance
6	Type 3-1	sand stone& mosaic faience	4	Domed chamber (transitional section)	-
7	Type 3-1	sand stone	4	naves	-
8	Type 3-1	sand stone	4	Corridors	-
9	Type 3-2	sand stone	4	-	Main vault of South &east entrance
10	Type 3-2	mosaic faience	4	*mihrabs*	-
11	Type 3-2	sand stone	4	Entrance of payer hall	-

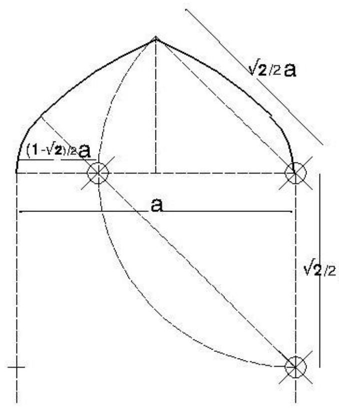


Figure 6.94: Type 3-1of Persian pointed arch, (Pirnia, 1991)

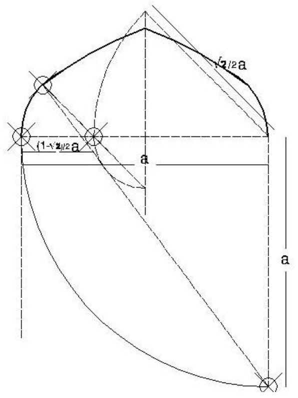


Figure 6.93: Type 3-2 of Persian pointed arch, (pirnia, 2001)

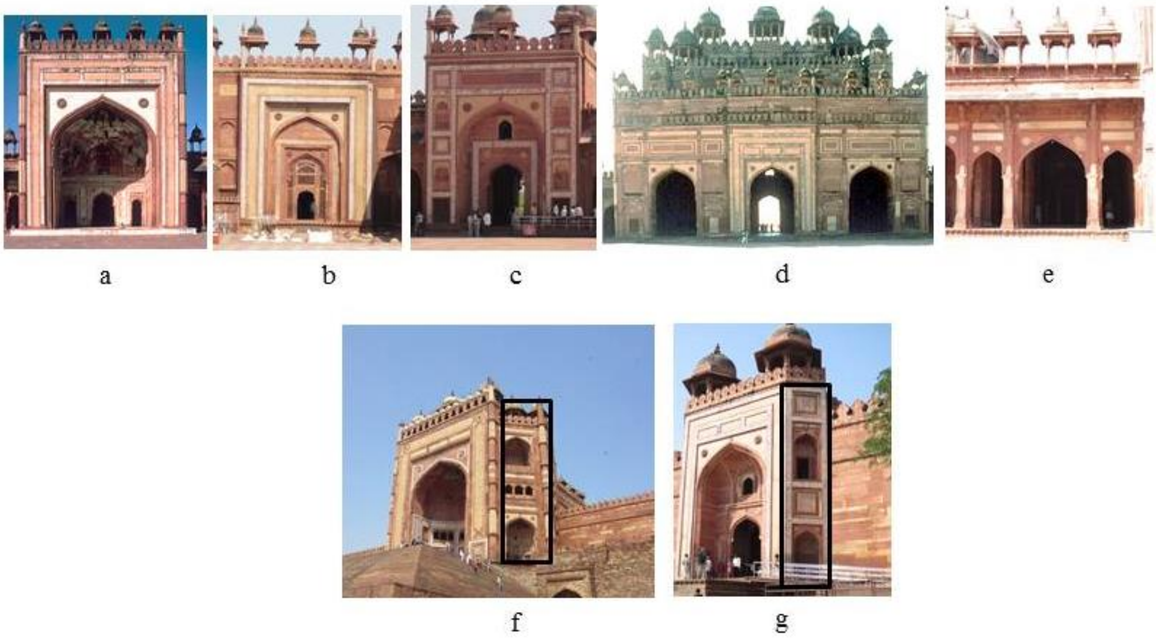


Figure 6.98: Arc type3-1 in outside: a) West *Ivan*, b) Entrance of tomb, c) East *Ivan*, d) South *ivan*, e) Courtyard ‘facade, f) Little arch of south entrance, g) Little arch of east entrance (Author-2012)

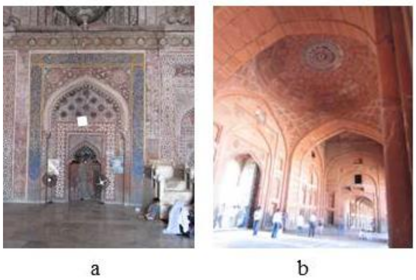


Figure 6.95: Using arch type 3-2 in inside: a*) Mihrab*, b) South entrance (Author-2012)

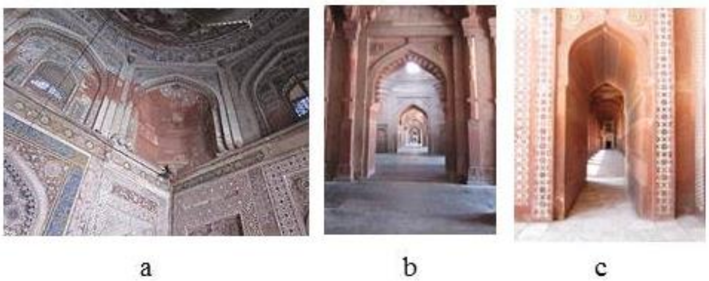


Figure 6.96: Using arch type 3-1 in inside: a) Domed chamber (transition system), b) Domed chamber (vault corridors),c) Corridors (Author-2012)

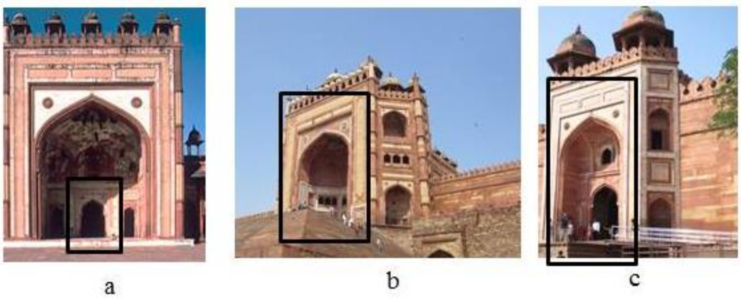


Figure 6.97: Using arch type 3-2 in outside a) Main vault bay in the west *ivan*, b)Main arch of south entrance , c) Main arch of east

6.7.Sixth case study: Taj Mahal mosque

Location**: Uttar Pradesh State, India**

Date: **1632-1648**

Building usage: **Mosque**

Figure 6.99: Mughal Empire map ("www.wikimedia.org,")

6.7.1.History

The Taj Mahal is a mausoleum complex in Agra built by Shah Jahan (reg. 1628 – 1658AD) in memory of his favorite wife, Arjumand Banu Begam (d.1631AD) (Figure 6.99), better known by her title "Mumtaz Mahal", or "the exalted one of the palace." It comprises of a number of buildings and structures, all functioning together as the funerary monument for Mumtaz Mahal. From the south, the first part of the complex consists of a (former) bazaar, the forecourt and entry gates; the second part consists of a large garden and garden pavilions, axially arranged along a riverfront terrace with the three main structures: the mosque, the mausoleum, and the *mihman khana* (literally, "guest house," probably used as an assembly hall)(Stierlin & Stierlin, 2002)(Figure 6.100).

With reference to Shah Jahan’s architecture in general, the style is essentially Persian, but sharply distinguished from the fashions of Isfahan (Safavid-author)(Smith, 1911). Taj Mahal should so often be regarded as the quintessence of the Mughal spirit, but, in the quality of its combination of monumentality and delicacy, and in the quality of its decoration, it represents the culmination, on Indian soil, of the Persian genius at work (Hambly & Swaan, 1968). Many names have figured as designers and craftsmen at the

Taj Mahal, such Muhammad Sharif Samarqandi, and its head sculptor was Ata Muhammad from Bukhara, and also Amanat Khan Shirazi as the writer of the Tughra inscription, Ustad Isa as the mason, were among some of the Persian master-artisans who were employed in Taj Mahal's construction. The Persians Ustad Isa Ahmad can be credited with much of the responsibility of the construction of Taj Mahal. He was paid a salary of one thousand rupees per month (Foltz, 1998; Goswami, Sarkor, & Saraswati, 1953; Mahajan & Mahajan, 1964; Sarkar, 1919)

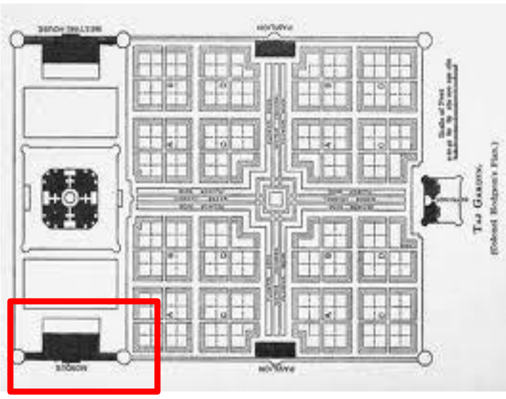


Figure 6.100: Mosque in Taj Mahal complex(Villiers & Constance 1913)

6.7.2. Architecture

The mausoleum is the dominant and unique feature in the center of the tripartite composition of the *qarina* scheme, and the lateral buildings, exactly alike, are the mirror–symmetrical components. Still, the mosque sets the tone, and as a religious building, gives the riverfront group additional gravity. The central building and flanking wings terminates at the towers set of the end of riverfront terrace, and provide the effect of a piazza around the mausoleum. Both mosque and *Mihman Khana* are proceeded by a large platform, or *Chabutra* (Koch & Barraud, 2006).

The mosque establishes the form that the *Mihman Khana* follows; it is based on standard type, which the Mughals took from the Sultanate architecture of Delhi, namely the oblong massive prayer hall formed by the vaulted bays and rooms arranged in an arrow, with a dominant central *pishtaq* and domes. Inside the mosque, the bays are half-like in dimension, and form the shape of the cross via arched recesses. The central hall is the largest: the dominant central dome flanked by two smaller ones reflecting a hierarchical grouping on the outside. In order to enrich the design, the central *pishtaq* was deepened, which allows the insertion of flanking rooms to be connected via linking passages, the plan was taken up in several later mosques, first the *Jami* mosque of Agra, and later the great *Jami* mosque of Delhi(Koch & Barraud, 2006).

6.7.3. Analysis

6.7.3.1. Ivan

Generally, *ivans* monumentally polarize the space of the courtyard and defines the main ax of it, but the Taj Mahal mosque does not have a special courtyard, and it only has one main *ivan* that is located opposite to the west *ivan* of Taj Mahal mausoleum. The main *Ivan* was distinguished from the other side of the facade by increasing the height and using the different materials (white marble and red sand stone). The large *Ivan (pishtaq*) is flanked by the standard superimposed niches, although those of the upper story are blind. The *pishtaq* is half-vaulted and faces the *qalib kari* (stalactites). The main *Ivan* is related to the domed chamber and corridors (see Figure 6.101, Figure 6.102 &Table 6.23).

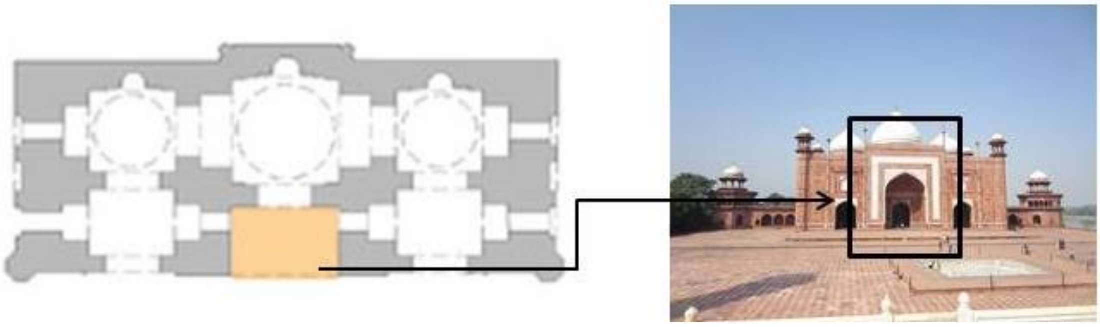


Figure 6.101: Position of *ivan* in plan with picture of *ivan*. ref of measure drawing(Koch & Barraud, 2006), ref of picture(Author-2012)

Figure 6.102: View from main *Ivan* to Taj Mahal tomb (left), main *Ivan* (right) (Author-2012)

With regards to Figure 6.103 , patterns one and four were applied vertically among the Persian geometrical patterns, while pattern four was used horizontally to the west of the *Ivan*.

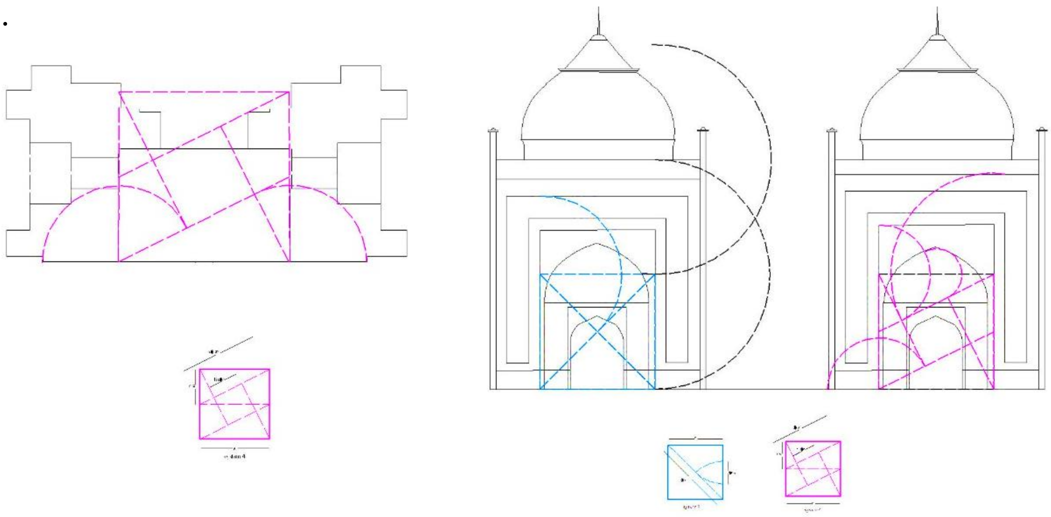


Figure 6.103: Geometrical analysis of *Ivan* (left), Geometrical analysis façade of Ivan (right) (Author-2012)

Table 6.23: General analsis of Ivans (Author-2012)

Ivan	shape	dimension			Elements of *Ivan "screen"*											material	relation		Location of the facade			Geometrical patterns	
		L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	Domed chamber	front	back	flat	plan	Façade
South *Ivan*	rectangular	21.5	7	23		✓	✓	✓	*	✓		✓	✓		✓	Marble and sand stone	-	✓	✓		✓	4	1,4

*Mini minarets

element of *Ivan* screen

1.inscription frieze
2.spandrel
3.band
4.plinth
5.minaret
6.scroll
7.blind arcade
8.open arcade
9.muqarnas
10.squnch net
11.parapet

6.7.3.2. Domed Chamber

Table 6.24: General analysis of domed chamber (Author-2012)

Domed chamber	shape	dimension			Elements of internal facade							relation			opening	material	Geometrical pattern	
					Load bearing		Transition section										plan	Façade
		L	W	H	1	2	1	2	3	4	5	*Ivan*	nave	*Mihrab*				
	Square	11	11	18	2	3	✓			✓	✓	✓	✓	✓	_	Red sand stone	1,4	1,4,8

load bearing system

1.blind arcade
2.open arcade

transition system

1.squinch
2.pendative
3.recumbent arch
4.arch-net (*squinch*-net)
5.muqarnas

The domed chamber of central hall is the largest – a hierarchical grouping that is reflected outside by the dominant central dome flanked by two smaller ones, is half-like in dimension, and forms a cruciform via arched recesses. It was connected to the spaces at the back by only one main vault bay at each side. The *mihrab* is located at the opposite of the main *Ivan*, and is highlighted by a marble frame with an inscription of the Sun (al-Shams) *sura*. The central domed chamber is entirely covered by several designs of ornamental cartouches and interlacing floral scrolls (see Table 6.24, Figure 6.104 & Figure 6.105).

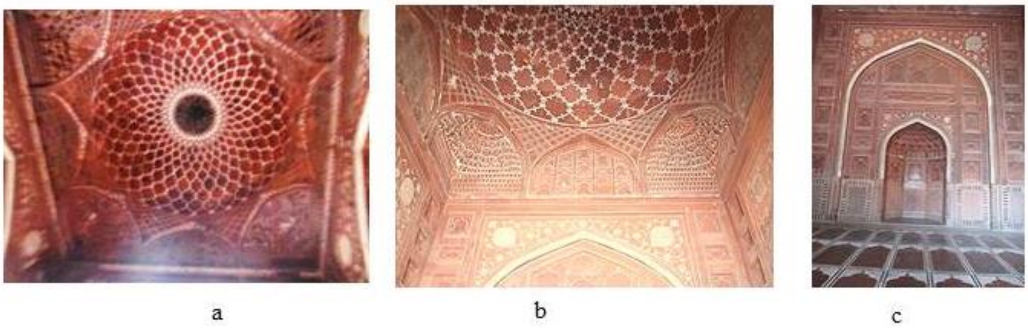


Figure 6.105: Domed chamber: a) Ceiling, b) Transition system, c) *Mihrab* (Author-2012)

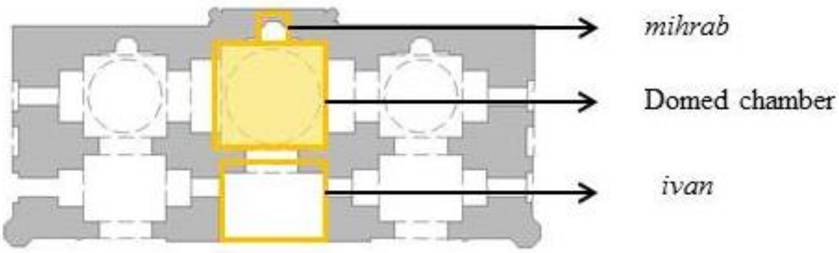


Figure 6.104: Combination domed chamber, *Ivan, mirab* ref of measure drawing(Koch & Barraud, 2006)

Based on Figure 6.107 & Figure 6.106, patterns one and four of the Persian geometrical pattern was applied for both façade and plan of domed chamber, while pattern eight was only present in the façade.

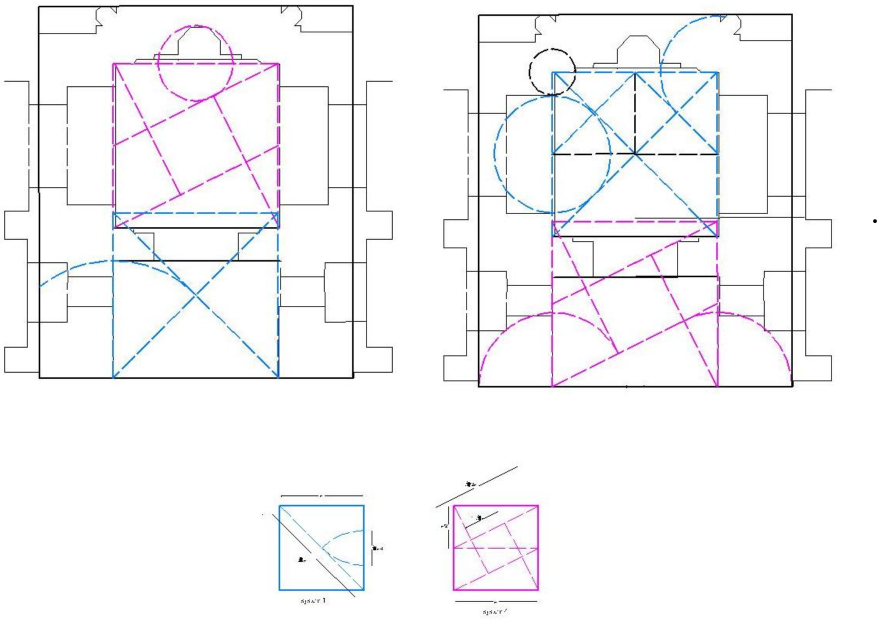


Figure 6.106: Geometrical analysis domed chamber (Author-2012)

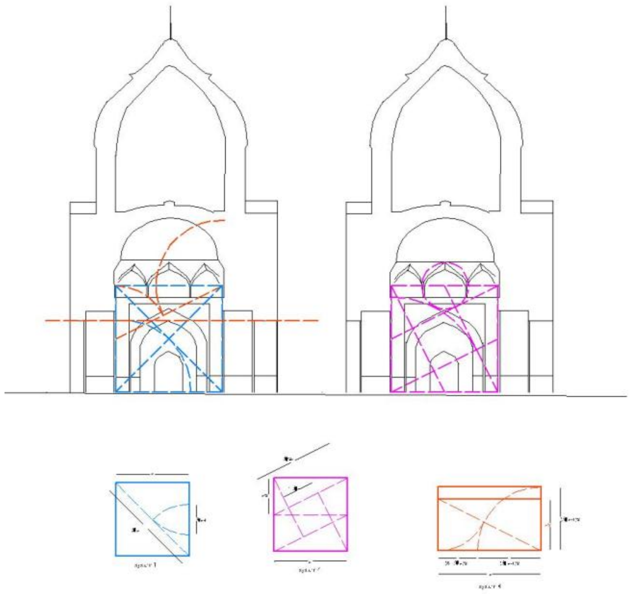


Figure 6.107: Geometrical analysis vertical elements of domed chamber (Author-2012)

6.7.3.3. Double Dome

Like the prevalent custom of Mughal mosques, Taj Mahal mosque has three domes, with the central one being the biggest. Each of three domes rests on a transitional zone of four arches and four *squinches.* The domes were composed of discontinuous double-domes with pointed arch for the external shell, circular eternal shell, and cylinder drum that was elaborated by white marble and red sand stone (refer to Figure 6.108, Figure 6.109& Table 6.25).

Table 6.25: General analysis of double dome (Author-2012)

type	Supporting system	Transition tier	C**	Type of internal shell		Type of external shell		drum	material	
				type	H*	type	H*	type	outer	inner
Discontinuous double dome	Square with bearing wall	Squinch+ muqarnas	31	circular	18	Bulbous	36.5	Cylinder	White marble	Red sand stone
		Squinch+ muqarnas	23.5	circular	15	Bulbous	30	Cylinder		

*Height from floor to end of dome C** circumference

a

b

c

Figure 6.108: Double dome: a) General view of domes, b) External shell and drum, c) Internal shell (Author-2012)

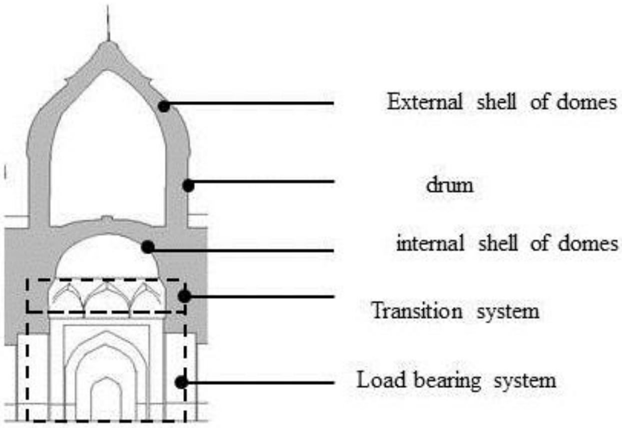


Figure 6.109: Transversal section , ref of measure drawing (Koch & Barraud, 2006)

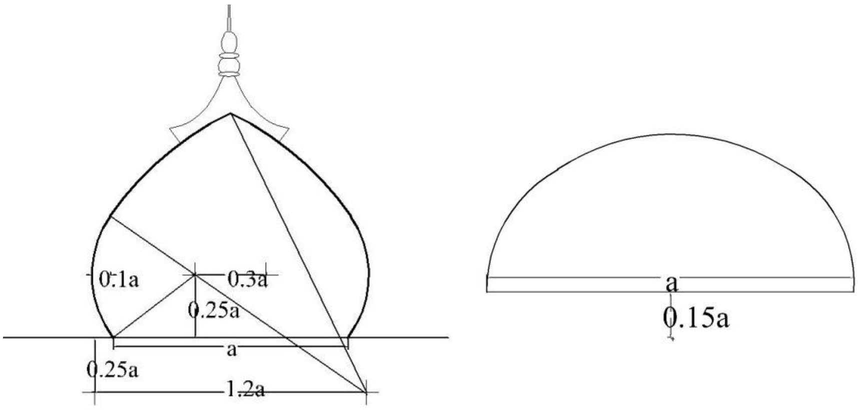


Figure 6.110, Geometrical analysis of external shell (left), Geometrical analysis of internal shell (right) (Author-2012)

6.7.3.4. Squinch

Each of three domes rests on a transitional zone of four arches and four *squinches*. The *squinches* was formed by a groined vault, and are filled by the *muqarnas*, or are otherwise found only in the baseline of the dome of a mausoleum (refer to Table 6.26, Figure 6.111).

Table 6.26: General analysis of *squinchs* (Author-2012)

type	material	Location		
		Ivan	Domed chamber	entrance
Groined vault with revetment of muqarnas	Red sand stone	-	✓	-

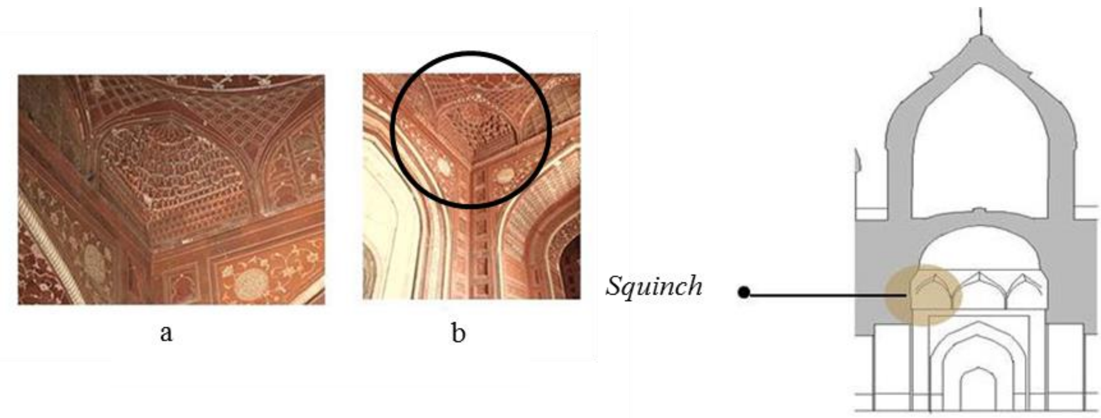


Figure 6.111: a)&b) *Squinch* (Author) ,Reference of measure drawing(Koch & Barraud, 2006)

6.7.3.5. Pointed Arch

Based on Figure6.115, Figure 6.112 &Table 6.27, type 3-1 and 3-2 from one category of Persian pointed arches (see Figure 6.114 & Figure 6.113) were used in this mosque. The ratio of using type 3-1 exceeds other types. It was applied in most spaces, such as the *mihrab*, main Ivan, courtyard and load bearing system of a domed chamber, and the type 3-2 can only be seen in a transitional system of domed chamber.

Table 6.27: General analysis of pointed arch (Author-2012)

	type	**material**	**Number of center**	**Location**	
				inside	Outside
1	Type 3-2	Red sand stone	4	Domed chamber transition system	-
2	Type 3-1	Red sand stone	4	Domed chambers load bearing system	-
3	Type3-1	Red sand stone	4	mihrab	-
4	Type 3-1	White marble	4	-	main *Ivan*
5	Type 3-1	Red sand stone	4	-	Court yard

Figure 6.112: Arch type 3-2 in transition system of domed chamber (Author-2012)

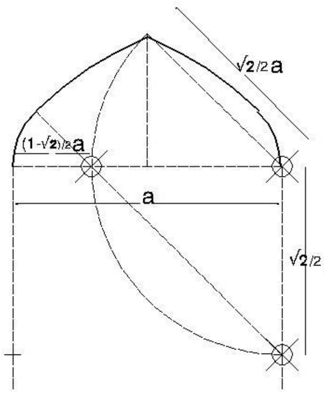


Figure 6.114: Type 3-2 of Persian pointed arch (pirnia, 2001)

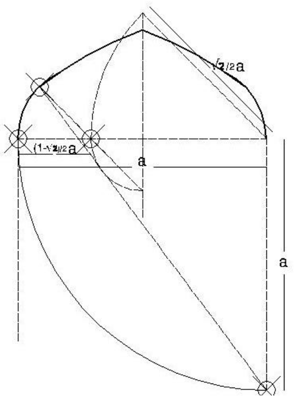


Figure 6.113: Type 3-1of Persian pointed arch (pirnia, 2001)

a b c

Figure 6.115 : Arch type 3-1 in : a)*Mihrab* , b) vault bay of domed chamber, c) external bay ,d)main *ivan* (Author-2012)

6.8. Seventh case study Delhi Jami mosque

- Location: **Old Delhi, India**
- Date: **1650-6**
- Building usage: **Jami Mosque**

Figure 6.2: Mughal Empire map ("www.wikimedia.org,")

6.8.1. History

The most important Indian mosque is the Jami Mosque (1650-6) of Shahjahanabad, the seventh city of Delhi where the emperor set up a new capital (see Figure 6.116). The mosque is also called the Masjid-i Jahanuma, or the mosque commanding a view of the world, as it is situated on a high plinth atop a natural hillock. It is located across the road on the west side of Red Ford, in the area known as Old Delhi. This mosque is the largest mosque in the Indian sub-continent, after the Jami mosque of Lahore (Pakistan). Due to its magnificence and size, the Jami Mosque of Old Delhi is often regarded as the apotheosis of Indian mosque design. Shah Jahan - the fifth Mughal ruler of India- ordered the construction of this mosque. The construction was supervised by Allami Said and Fazl Khan(Aziz-Ur-Rahman.R, 1987; Khan, Al-Asad, & Frishman, 1994; Stierlin & Stierlin, 2002).

6.8.2. Architecture

Delhi‘s Jami mosque is considered to be the epitome of Shah Jahan‘s elegant and luxurious classical style. It is one of the largest examples of four *Ivan* mosques in India based on the Persian Four *Ivan* plan. The exterior of the Jami Mosque was modeled after

Akbar's mosque at Fatehpur Sikri, while its interior is akin to the Jami Mosque at Agra (Tadgell, 1994).

The mosque is constructed upon a raised platform that lead to three stairs from the north, south, and east entrance. The eastern monumental entrance resembles the *Boland Darwaza* gateway in Fatehpur Sikiri mosque. The main entrance is raised to the height of three articulated stories. The prayer hall is large space with three substantial domes and a massive *pishtaq*, mirroring the eastern entrance. Two minarets, each divided into three stages by an equal number, act as flanks. The Haram, or prayer hall, is projected into the court as a totally freestanding block. It consists of two lateral bays – the open area in the east, and the separate space in the west ending at the *qibla*. The enclosed space of the Delhi Mosque was designed based on its hierarchy. An observer will first come across the *Ivan*(Bunce, 2008; Desai, 1971; Tadgell, 1994).

Despite the overall vast properties of the mosque, its various component parts have been blended together in such perfect harmony and effortless homogeneity that it results in a magnificent great beauty and elegance (Desai, 1971).

6.8.3. Analysis

6.8.3.1. Ivans

Delhi Jami mosque followed the four *ivans* mosques as one of most prevalent type of Mughal mosques. Three of these were merged with the entrance and appears different from the west *Ivan* (*ivan* that is connected to domed chamber). East *Ivan*, with the red sand stone material are related to the main entrance, and originally are reserved for the king. It is three stories high, with small-attached minarets, while its northern and southern parts are only two stories tall. The rear wall of the *ivans* is punctuated by an double-height arched doorway leading into the domed interior, and all *ivans* have the adjacent chambered faces. The west *Ivan* however, has a different face compared to the others. It has one story level, with a huge arch and slender minarets at its corners. It is covered with semi domes ,and ornamented by a combination of white marble and red sand stone (refer to Figure 6.117 &Table 6.28).

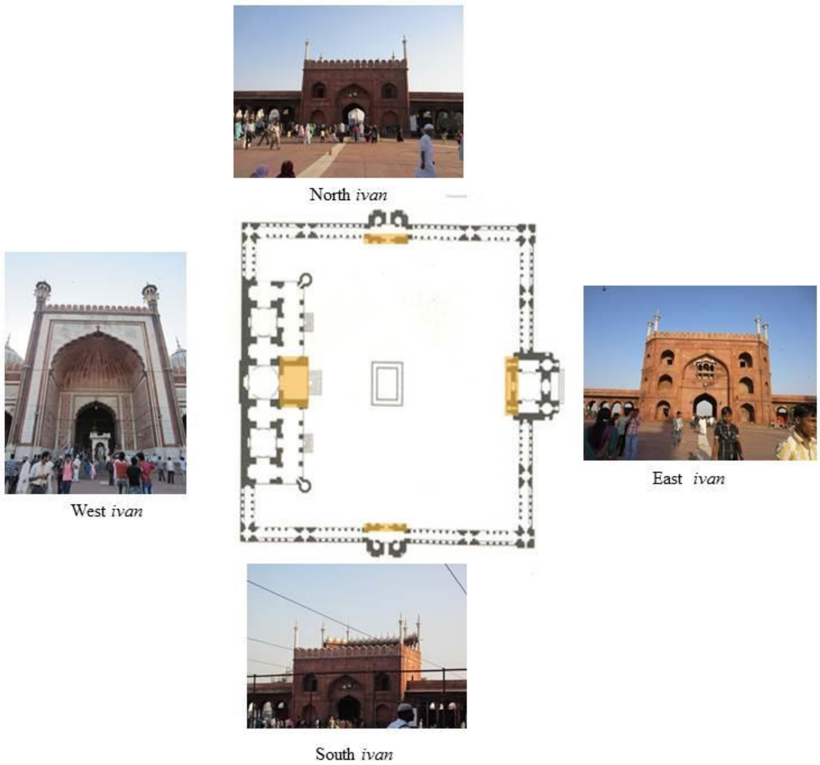


Figure 6.117: Position of Ivans in pelan with picture of *ivans*. ref of measure drawing(Bunce, 2008), ref of picture (Author-2012)

Based on Figure 6.118, Figure 6.119, Figure 6.120, Figure 6.121, Figure 6.122 & Figure 6.123, Persian geometrical patterns of one, two and four can be found in the façade of all *Ivan*, excluding the east. In façade east one, patterns one, two, and five can be realized. In the plan of all *ivans*, pattern four was used, but pattern three in the west *ivan* and pattern one in the east *ivan* were also visible.

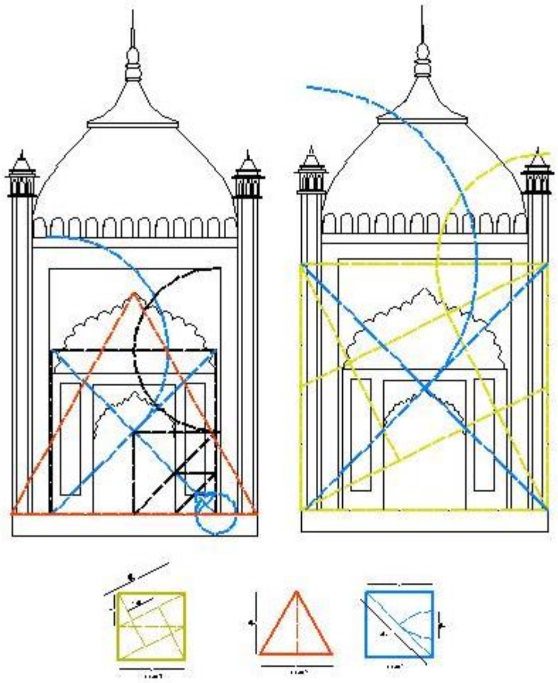


Figure 6.119: Geometrical analysis façade of west *Ivan* (Author-2012)

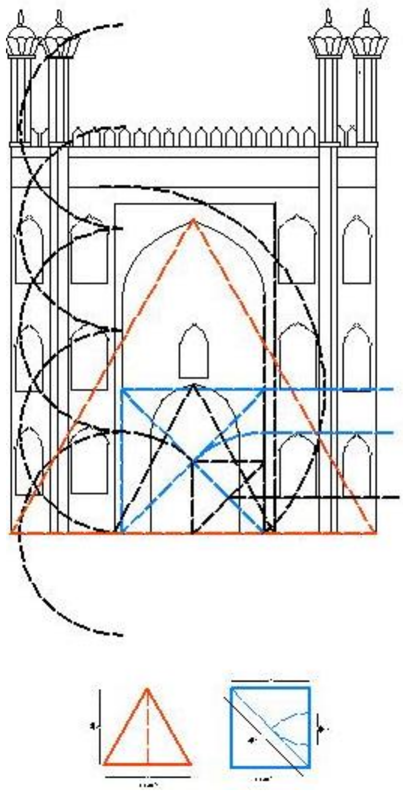


Figure 6.118: Geometrical analysis façade of east *Ivan* (Author-2012)

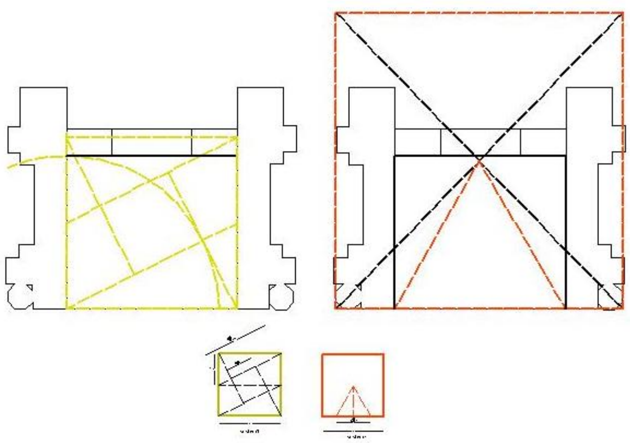


Figure 6.120: Geometrical analysis plan of west *Ivan* (Author-2012)

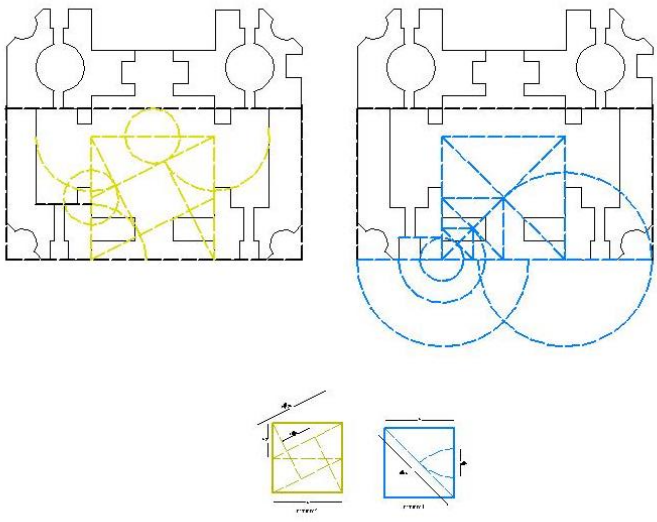


Figure 6.121: Geometrical analysis plan of east *Ivan* (Author-2012)

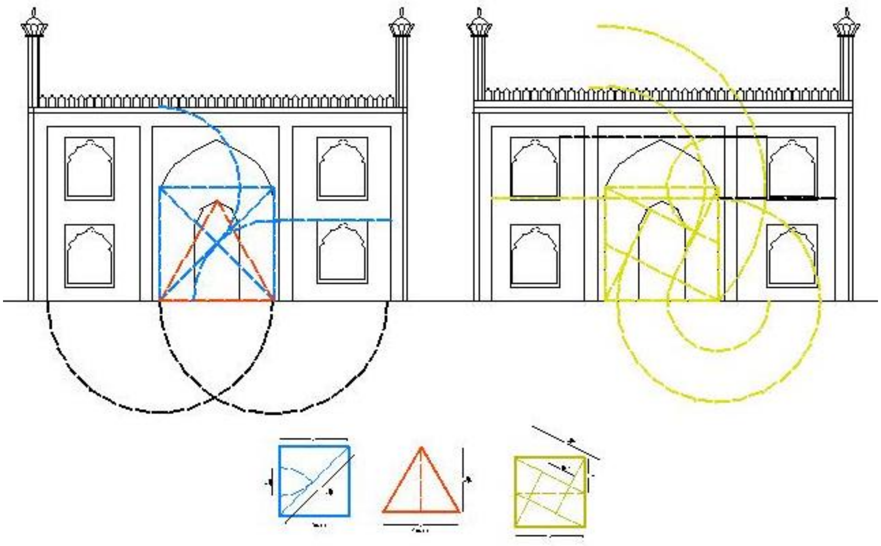


Figure 6.122: Geometrical analysis plan of north and south *ivans* (Author-2012)

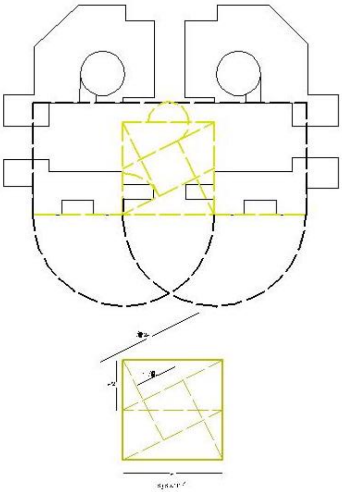


Figure 6.123: Geometrical analysis façade of north and south *ivans* (Author-2012)

Table 6.28: General analsis of *ivans* (Author-2012)

Ivan	shape	dimension			Elements of *Ivan "screen"*											material	relation		Location of the facade			Geometrical patterns	
		L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	Domed chamber	front	back	flat	plan	Façade
west *ivan*	rectangular	14.5	7.5	22		✓	✓	✓	✓			✓			✓	White marble & red sand stone	-	✓	✓			3,4	1,2,5
east *ivan*		19	10.5	25		✓	✓	✓	*		✓	✓			✓	Red sand stone	corridors	-	✓			1,4	1,2,5
north *ivan*		12.3	5	20		✓	✓	✓	*		✓	✓			✓				✓			1,4	1,2,4
South *ivan*		12.3	5	20		✓	✓	✓	*		✓	✓			✓				✓			1,4	1,2,4

*mini minaret

element of *Ivan* screen
1.inscription frieze
2.spandrel
3.band
4.plinth
5.minaret
6.scroll
7.blind arcade
8.open arcade
9.muqarnas
10.squnch net
11.parapet

6.8.3.2. Domed Chamber

Table 6.29 : General analysis of domed chamber (Author-2012)

Domed chamber	shape	dimension			Elements of internal facade							relation			opening	material	Geometrical pattern	
					Load bearing		Transition section										plan	Façade
		L	W	H	1	2	1	2	3	4	5	*Ivan*	nave	*Mihrab*				
	Square	9.5	9.5	12.5	2	3	✓		✓			✓	✓	✓	_	Red sand stone	1,3,4	1,2,4

load bearing system
1.blind arcade
2.open arcade

transition system
1.squinch
2.pendative
3.recumbent arch
4.arch-net (*squinch*-net)
5.muqarnas

A domed chamber acts as a central section of a prayer hall, and accession is in an identical manner to the other bays and the west *Ivan* with four large multi-cusped vaults. The blind vault in the west side is regarded as a *mihrab*, formed of cusped arches set in a rectangular frame, and is completely clad in white marble with intricate embossed tracery. The whole space is encompassed by red sandstone arch and white marble inlay works (Figure 6.124, Figure 6.125 &Table 6.29).

a b c

Figure 6.124: Domed chamber a) Load bearing system, b) *Mihrab*, c) Transition system (Author-2012)

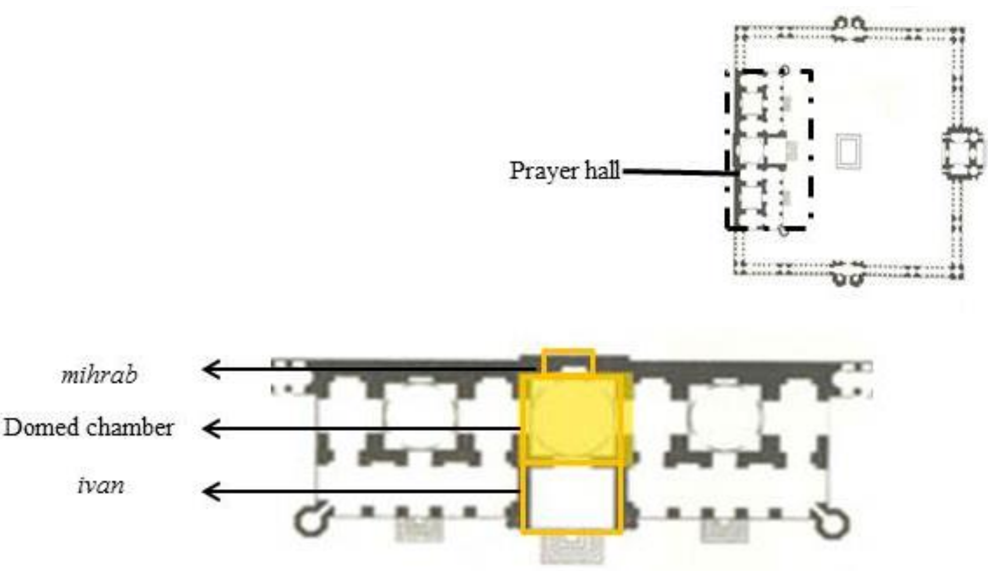


Figure 6.125: Combination domed chamber, *Ivan, Mihrab*
ref of measure drawing(Bunce, 2008)

With regards to Figure 6.126 , Figure 6.127 & Figure 6.128 , Persian geometrical patterns one and four were utilized in both the façade and plans of a domed chamber, but two different patterns can be seen specifically for each of plan and façade: pattern two (in the façade) and pattern three (in the plan).

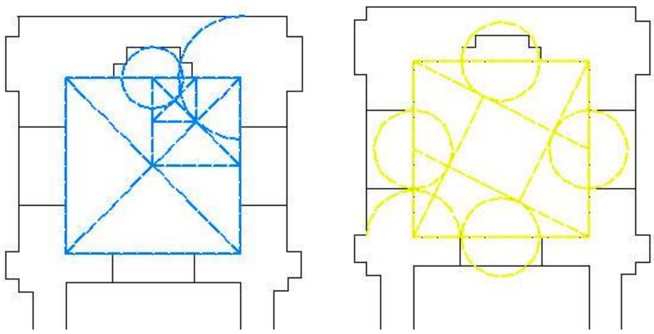


Figure 6.126: Geometrical analysis of domed chamber (Author-2012)

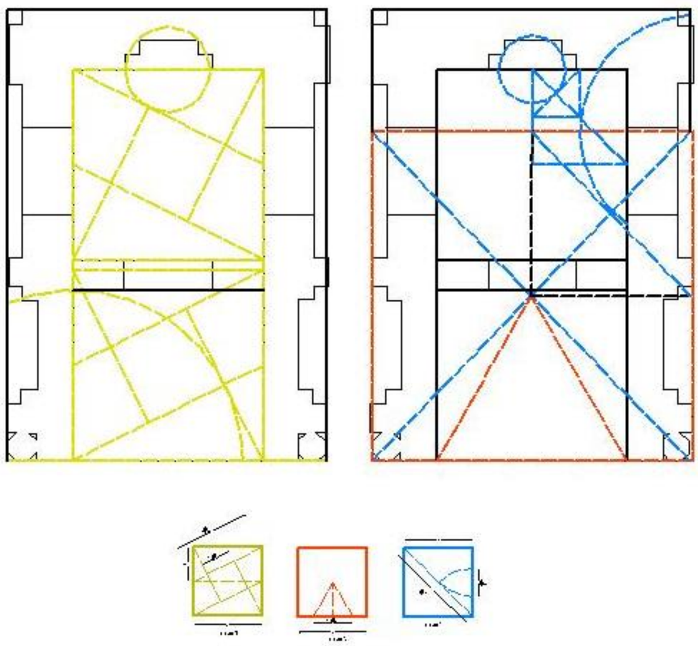


Figure 6.127: Geometrical analysis of combination domed chamber, *ivan, mihrab* (Author-2012)

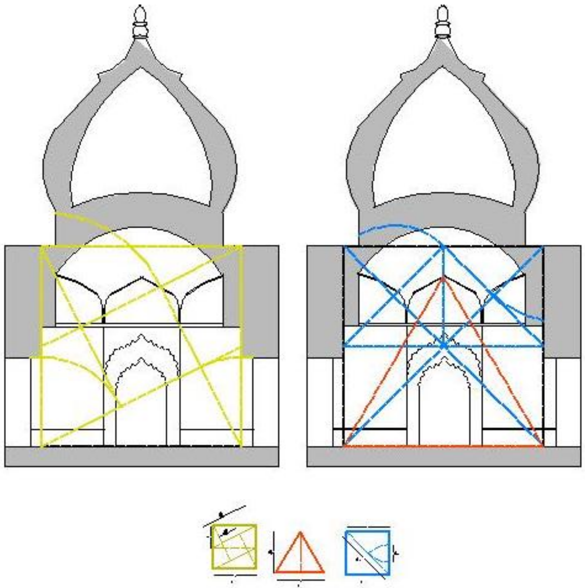


Figure 6.128: Geometrical analysis section of domed chamber (Author-2012)

6.8.3.3. Double Dome

The three double domes rise over the second, fourth, and sixth bays of the prayer hall. The middle one covering the dome is the biggest one of them all. All of the domes are covered with white marbles, are inlaid with black marble strips, and are externally topped by golden finials, and internally by red sand stones. Domes are categorized into discontinuous double domes with bulbous type for external and pointed dome for the internal (seeTable 6.30, Figure 6.129, Figure 6.130, Figure 6.131).

Table 0.1: General analysis of double dome (Author-2012)

type	**Supporting system**	**Transition tier**	**C****	**Type of internal shell**		**Type of external shell**		**drum**	**material**	
				type	H*	type	H*	type	outer	inner
Discontinuous double dome	Square with bearing wall	*Squinch*	38	circular	12.5	Bulbous	29.5	Cylinder	hite marble	Red sand stone
		Squinch	30	circular	9.7	Bulbous	23	Cylinder		

*Height from floor to end of dome C** circumference

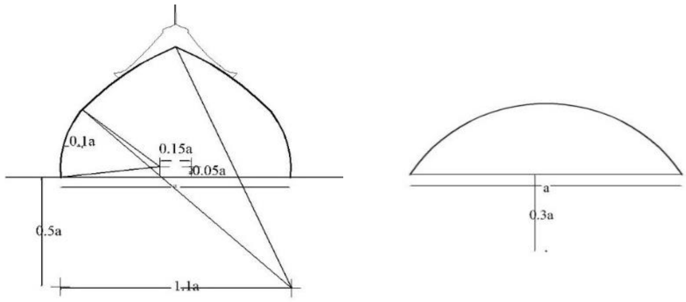


Figure 6.130: Geometrical analysis of external shell (left), Geometrical analysis of internal shell(right) (Author-2012)

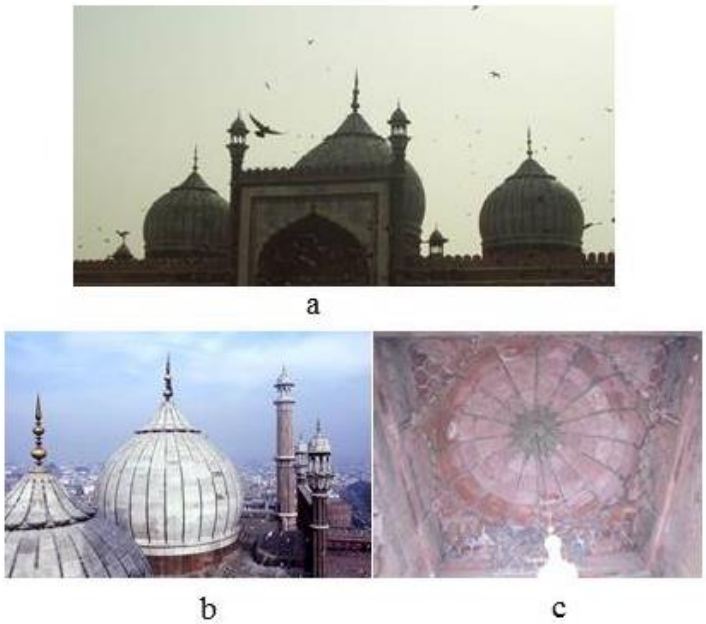


Figure 6.129 : Double dome: a) General view of domes, b) External shell, c) Internal shell (Author-2012)

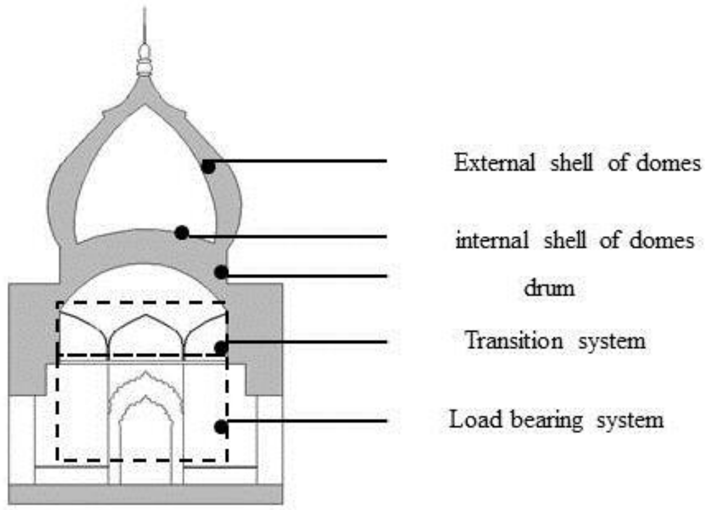


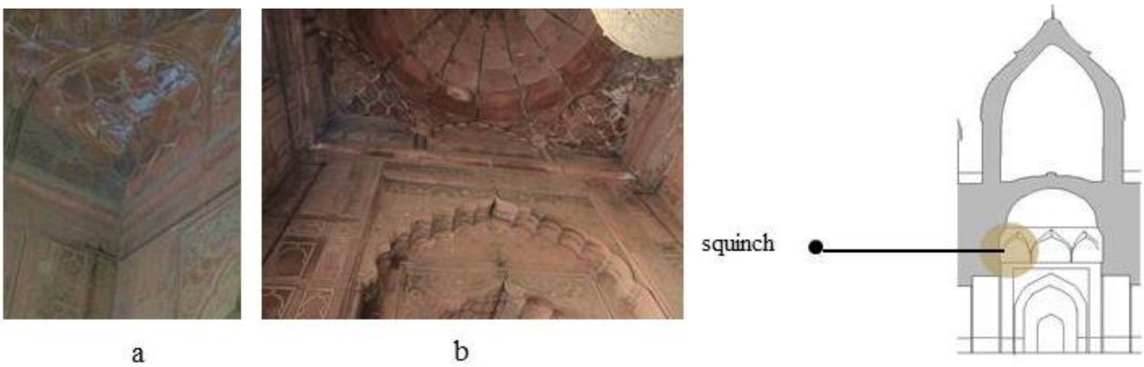
Figure 6.131 : Transversal section, ref of measure drawing (Author-2012)

6.8.3.4. Squinch

Among various types of Persian *squinch*, the groined vault was used in the domed chamber and east entrance hall (see Figure 132, Figure 133 &Table 31).

Table 7.31, General analysis of *squinch* (Author-2012)

type	material	Location		
		Ivan	Domed chamber	entrance
Groined vault	Red sand stone	-	✓	-
Groined vault	Red sand stone			✓East entrance hall



a b

Figure 7.132, a) &b) *Squinch* in domed chamber (Author-2012)

Figure 7.133 : *Squinch* in east entrance (Author-2012)

6.8.3.5. Pointed Arch

The most prevalent arch type in Delhi Jami Mosque is cusped arch as non–Persian type, even though type 3-2 of Persian arches was used in the entrances and *ivans* exclusion of west *ivan*. By comparing the cusped arch and 3-2(refer to Figure) of Persian arches, it is obvious that the base pattern of the cusped arch is very similar to type 3-2 in this building (refer Figure 6.136, Figure 6.135 &Table 6.32).

Table 6.32: General analysis of pointed arch (Author-2012)

	type	material	Number of center	Location	
				inside	Outside
1	Type 3-2	Sand stone	4	-	north *ivan*
2	Type 3-2	Sand stone	4	-	South ivan
3	Type3-2	Sand stone	4	-	east ivan
4	Type 3-2	Sand stone	4	East entrance	East entrance
5	Type 3-2	Sand stone	4	North entrance	North entrance
6	Type 3-2	Sand stone	4	South entrance	South entrance

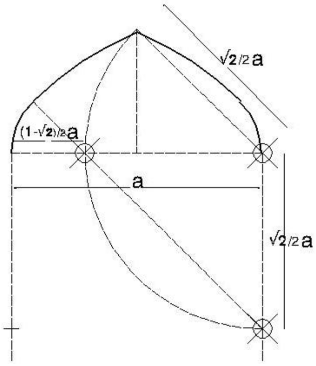


Figure 6.135: Type 3-2 of Persian pointed arch (pirnia, 2001)

a b

Figure 6.134: Cusped arch in: a) west *Ivan*, b) courtyard (Author-2012)

a b c

Figure 6.136: Using arch type 3-2: a)main arch of east *ivan* and east entrance, b) main arch of north &south *ivans* and entrances, c) interior f east entrance(Author-2012)

CHAPTER 7: RESULTS AND DISCUSSION

7.1. Introduction

The aim of this chapter is to discuss the results obtained from the case study analysis. It comprises three phases. Figure 7.1 shows the structure of data analysis and its relevance to the research objectives. The first phase specifies the results and discussion of comparisons between Timurid case studies that encompass the second objective. The next phase explains the results and discussion of the second and third propositions mentioned in 3.3 (The second proposition is directly influenced by Timurid dynasty in Mughal buildings, while the third one is influenced by the Persian period (Safavid) that is a contemporary of Mughal buildings).

The first level of phase two is the results and discussion of the comparison between Timurid and early Mughal case studies (based on second proposition). While the second and third level are the results of the comparison between Timurid and Safavid case studies, and then Safavid and high Mughal periods (according to third proposition), where all these levels cover objective three. The final phase describes the comparative results of Mughal case studies that address objective four.

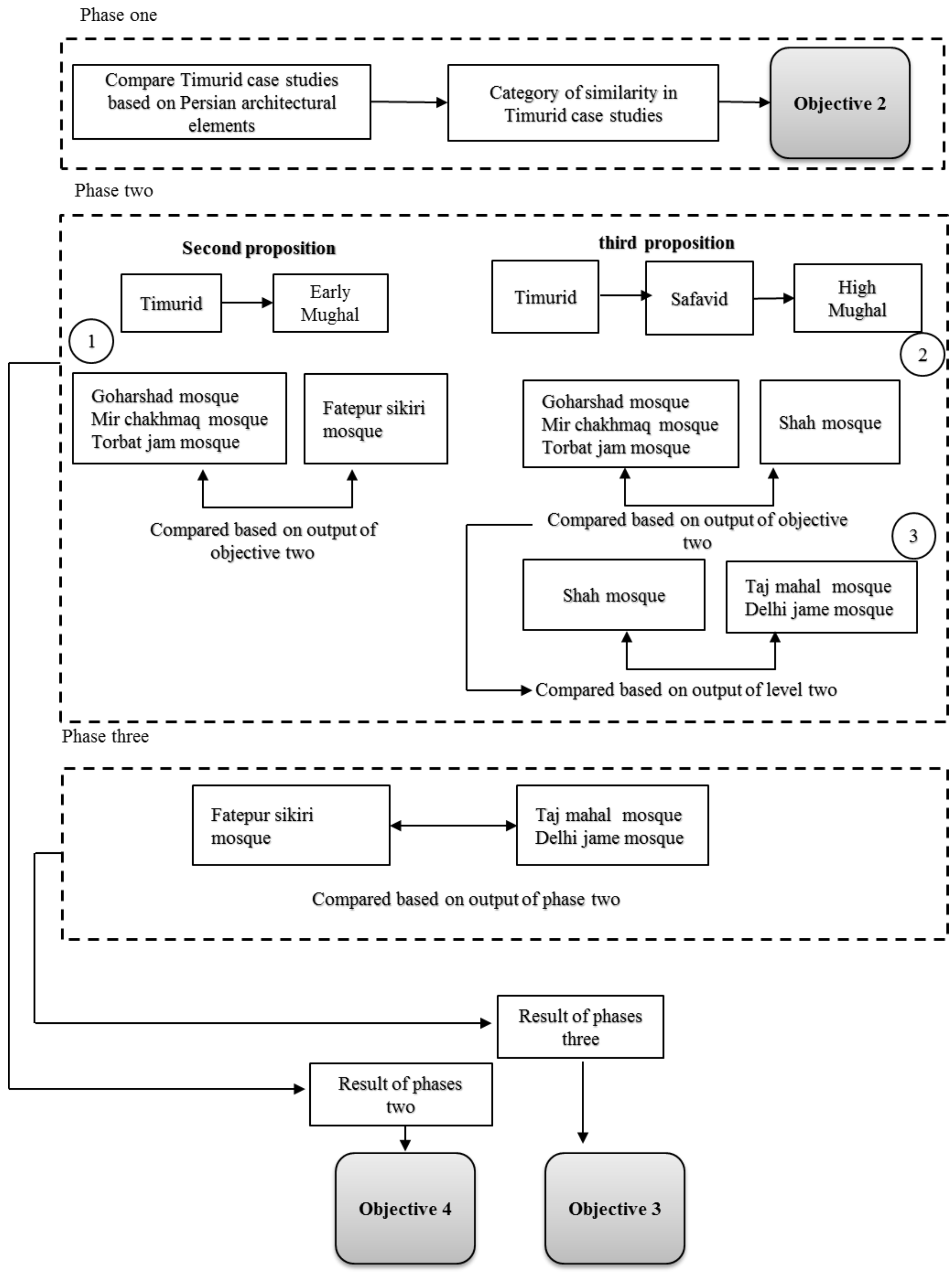


Figure 7.1: Structure of data analysis and the relevance to the research objectives

7.2.Phase One: The Comparison between Timurid Case Studies

Ivans

Ivans had a fundamental role in Persian architecture, especially in mosques. Based on section 4.4.1 (literature review), Ivan monumentally polarizes the space of courtyard and defines the main axis as an intermediate between indoors and outdoors.

All Timurid case studies, with the exception of the mosque of Torbat Jam, followed the most popular Persian mosque, namely four *ivans* mosque that were adapted from the Seljuk, developed, and flourished until the Safavid period. In addition, this model of *Ivan* has also been continued in its typical form, especially for congregational mosques (refer to Figure 7.2).The Mosque of Torbat Jam was designed based on another famous model: Mosque with one or two *ivans*, widespread particularly in the east of Persia.

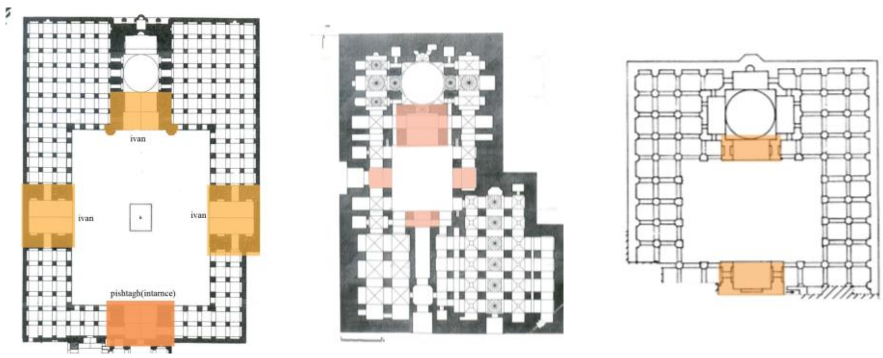


Figure 7.2: Position of *ivans* in case studies (Author-2012)

7.2.1.1. Relations of Ivans:

Gohar Shad mosque: The south *ivan* was abutted to the domed chamber without any barrier (blind arch or vaulted tunnel), and both of these spaces have identical length and are composed of one unit. Moreover, the south of the *Ivan* is only related to the domed chambers and not to the naves, but the other *ivans* are related to the naves and adjacent spaces (Holy shrine of Imam Reza) by vaulted tunnels (Figure7.4).

Mir chakhmaq mosque: The south *ivan*, as the main *Ivan*, was bigger and deeper than the other *ivans* compared to the south *Ivan* of the other Timurid case studies. All *ivans* were related to naves, domed chamber (for south Ivan), and main corridors (for north and east *ivans*) by vaulted tunnels (Figure7.3).

Mosque of Torbar Jam: The south *ivan*, like Goharshad mosque, is only connected to the domed chamber (*Ivan* was part of cruciform shape of domed chamber) and the north *Ivan*, like Goharshad mosque, is connected to the shrine of Sheikh Aahmad Jami (Figure7.4).

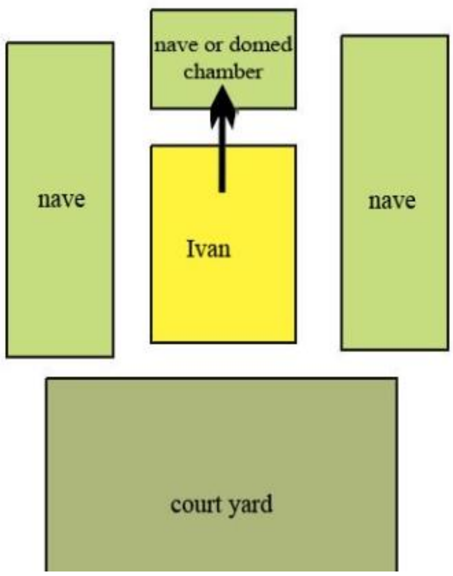


Figure 7.4: Pattern 1 of Ivan's relation to other functional elements (Author-2013)

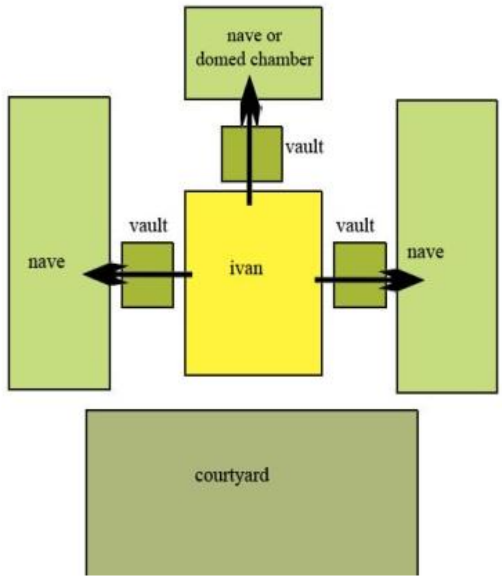


Figure 7.3: Pattern 2 of Ivan's relation to other functional elements (Author-2013)

7.2.1.2. Form

The typical horizontal form of the *ivan* is rectangle in Islamic Persian mosques. All Timurid case studies also followed suit, despite the fact that the ratios of length-to-width are different (more information in 7.2.1.VI). The depth of the *ivans* in each mosque is irregular; a response to the location and importance of spaces in the back of *ivans*.

7.2.1.3. Structure of Ceiling

All *ivans* of the first and second Timurid case studies are covered by vaulted tunnels, but in the mosque of Torbat Jam, the vault of *ivans* have additional plaster revetment of *squinch*-net (arch-net) (Figure).

7.2.1.4. Material

The dominant material in the Timurid period was mosaic fiancé, chiefly for outdoor spaces. Among Timurid case studies, the mosaic fiancé was utilized in Goharshad and Mir Chakhmaq mosques. The first mosque was famous for its mosaic decoration, with *ivans* enclosed panels of mosaic fiancé and brickwork on a high base of marble revetment. The second one was inferior to the mosaic decoration compared to Goharshad mosque. The main materials of *ivans* are mosaic faience (blue, yellow, white, black) within patterned brickworks. Unlike the previous two samples, the *Ivans* in the mosque of Torbat Jam were internally decorated by plaster and externally by brick (Figure7.5).

Goharshad mosque Mir Chakhmaq mosque mosque of Torbat Jam

Figure 7.5: General view of south *ivans* (Author-2012)

7.2.1.5. Elements of Ivan 'Façade

Based on the information in 4.4.1.VI in the literature review, the elements of Timurid *ivans* screen can be discussed as follows:

South *ivan*: With the exception of Goharshad mosque that had great scale compared to other Timurid case studies, the typical form of south *ivans* are comprised of a band throughout *Ivan,* a spandrel, a plinth, and an open arch. However, in the first sample, the inscription frieze and two big minarets extending to the ground were inserted to the south of the *Ivan*. The system of structure in all samples was vaulted tunnels; however, the revetment of *squinch*-net (arch-net) was the covered vault in the mosque of Torbat Jam. The first mosque was designed without any wall between the *Ivan* and domed chamber, while in the second; the additional open arch was located above the entrance arch (see Table).

North, West, and East *ivans:* These *ivans* in the Timurid samples are similar to the typical form of the south of the *Ivan* that includes a band throughout the *Ivan,* a spandrel, a plinth, and an open arch. Only the mosque of Torbat Jam had the additional decoration of *squinch*-net (see Table 7.1).

Table 7.1: General analysis of *ivans* (Author-2012)

	mosque	**shape**	**dimension**			**Elements of *Ivan* "screen"**											**material**	**relation**		**Location of the facade**			**Geometrical patterns**	
			L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	*Mughsura*	front	back	flat	plan	Façade
South Ivan	Gawhar Shad Mosque	rectangular	36	18	36	✓	✓	✓	✓	✓			✓				Fiancé Mosaic		✓	✓			3,4	1,2,5, 8
South Ivan	Mir Chaqmaq Mosque	rectangular	13	10.5	15		✓	✓	✓				✓				Fiancé Mosaic		✓			✓	1, 3,4	1,2,4, 5,8
South Ivan	Mosque of Torbat-i-Jam	rectangular	12	8.5	12	✓	✓	✓	✓				✓		✓		Brick	✓	✓			✓	3,4,5	1,2,5, 8
North Ivan	Gawhar Shad Mosque	rectangular	31	25	34	✓	✓	✓	✓				✓				Fiancé Mosaic	✓				✓	1,3,4	1,8
North Ivan	Mir Chaqmaq Mosque	rectangular	8.6	6	8.5	✓	✓	✓	✓				✓				Fiancé Mosaic	✓				✓	1,3,4	1,2,5, 8
North Ivan	Mosque of Torbat-i-Jam	rectangular	12	9.5	12	✓	✓	✓	✓				✓		✓		Brick	✓				✓	3,5,9	1,2,5, 8
east & west Ivan	Gawhar Shad Mosque	rectangular	31	25	34	✓	✓	✓	✓				✓				Fiancé Mosaic	✓				✓	1,3,4	1,8
east & west Ivan	Mir Chaqmaq Mosque	rectangular	10	7	10	✓	✓	✓	✓				✓				Fiancé Mosaic	✓				✓	1,3,4	1,2,5, 8
east & west Ivan	Mosque of Torbat-i-Jam		-	-	-	-	-	-	-				-			-	-	-	-	-	-	-	-	-

element of *Ivan* screen

1.inscription frieze
2.spandrel
3.band
4.plinth
5.minaret
6.scroll
7.blind arcade
8.open arcade
9.muqarnas
10.squnch net
11.parapet

7.2.1.6.Geometrical System and Proportions of Ivans:

South *Ivan*: With regard to Table D-1in the Appendix D, Persian geometrical systems in both façade and plan of Timurid south *ivans* are displayed in Table . More similarities can be seen in the façade rather than the plan. In the façade of the Timurid case studies, the most useful systems were one, two, five& eight, while systems 3 and 4 are the most useful patterns in the plan of Timurid case studies.

Moreover, the proportions based on the results of Table D-1 (in the Appendix D) were summarized in Table 7.2, and, were refined in Table 7.3. The proportions of Timurid south *Ivan* can be described in the following form:

The ratio of length-to-width and height in all south *ivans* of Timurid case studies are dissimilar. The main reason is the lack of identical sizes of mosque, especially courtyards, along with the effect of courtyard sizes in proportion to the *ivans*. Two samples, Mir Chakhmaq and mosque of Torbat Jam, have small courtyards (24*26 and 30*23, respectively), but Goharshad mosque was the congressional mosque with a great yard (50*55). The ratio of length-to-width and height in the two small mosques is similar, and in Goharshad mosque, it is bigger due to the insert minaret and size of the courtyard, despite the fact that the ratio of length-to-height in all Timurid case studies is similar.

Table 7.2: Proportions of *south Ivan*'s façade based on geometrical patterns (Author-2013)

name of mosque	length	width	height	height of minarets	height of dome
Gawhar Shad Mosque	$\sqrt{5}a$	a	$(\sqrt{15}(\sqrt{2}-1)a$	$\frac{3\sqrt{5}}{2}a$	$\frac{3\sqrt{5}}{2}a$
Mir Chaqmaq Mosque	$\sqrt{3}a$	$\frac{(\sqrt{3}+1)a}{2}$	2a	-	$(\sqrt{3}+2)a$
Mosque of Torbat	$\sqrt{3}a$	$(\sqrt{3}-1)a$	$\frac{(\sqrt{2}+2)a}{2}$	-	-

Table 7.3: Proportions of south *Ivan* (Author-2013)

name of mosque	length	width	height	height of minarets	height of dome
Gawhar Shad Mosque	A	0.5A	A	1.5A	1.5A
Mir Chaqmaq Mosque	A	0.8A	1.1A	-	2.1A
Mosque of Torbat	A	0.7A	A	-	-

Tables E-1 and E-2 in the Appendix E represent the proportions of Timurid south *Ivans*'s plan and façade for minor dimensions. Generally, the major dimensions (e.g. the total length of Ivan) are similar compared to the minor ones (e.g. the length of Ivan 'entrance opening). Within these minor demotions, the vertical elements are similar in proportion compared to the horizontal elements, because other functional sections such as influenced the second group: domed chamber and naves. Among the vertical minor dimension of the *Ivan* screen, the length of the opening to the backspace (A_1) and the height of the *Ivan* (from the ground to top of spandrel-B_3) are similar in Timurid case studies. This makes it prudent to omit the minor dimension for the next phase of the result, leaving only the major dimension for analysis.

North, east, and west *Ivans* undergo a similar process in locating geometrical systems and proportions in the south *ivans*, and the results from Table D-2 in the Appendix D are displayed in Table (geometrical patterns) and Table 7.4 &Table 7.5 (For proportions), and then were summarized and reviewed in Table 7.6 & Table 7.7 (for proportions).

Similar to the south *Ivan*, geometrical systems one, two, five, and eight are the most used systems in the facade of the north *Ivan* (the same east and west *Ivans*) in the Timurid samples, while geometrical systems 1, 3, and 4 are visible in the plan of all Timurid case studies.

In comparison to the south Ivan, other *Ivans* of Timuird samples match the ratio of length-to-width and height, and have similar proportions with the notable exception of the north Ivan of Mir Chakhmaq, which was related to the long corridors.

Minor proportions (refer to Table E-3, Table E-4, Table E-5& Table E-6 in the Appendix E), like the south *Ivan*, are less similar to the major ones, and within the minor demotions, the vertical elements have more similar proportion compared to their horizontal counterparts. Consequently, the minor dimension can be omitted in further phases of the results.

Table 7.4: Proportions of north Ivan's façade base on geometrical patterns (Author-2013)

name of mosque	length	width	height
Gawhar Shad Mosque	√3a	$\frac{(1+\sqrt{5})}{\sqrt{5}}a$	2a
Mir Chaqmaq Mosque	√3a	$\sqrt{3}\,\frac{\sqrt{2}a}{2}$	$\frac{(\sqrt{2}+2)a}{2}$
Mosque of Torbat	√3a	$\frac{(1+\sqrt{5})a}{2\sqrt{5}}$	$\frac{(\sqrt{2}+2)a}{2}$

Table 7.5: Proportion of north Ivan (Author-2013)

name of mosque	length	width	height
Gawhar Shad Mosque	A	0.8A	1.1A
Mir Chaqmaq Mosque	A	0.4A	A
Mosque of Torbat	A	0.8A	A

Table 7.6, Proportions of east and west Ivan's façade base on geometrical patterns (Author-2013)

name of mosque	length	width	height
Gawhar Shad Mosque	√3a	$\frac{(1+\sqrt{5})}{\sqrt{5}}a$	2a
Mir Chaqmaq Mosque	√3a	$\frac{(2\sqrt{3}-1)a}{2}$	$\frac{(\sqrt{2}+2)a}{2}$

Table 7.7: Proportion of east and west *Ivans* (Author-2013)

name of mosque	length	width	height
Gawhar Shad Mosque	A	0.8A	1.1A
Mir Chaqmaq Mosque	A	0.7A	A

7.2.2. Domed chamber

7.2.1.1.Form

Generally, in Timurid architecture, the common derived shape of the mosque's domed chamber is almost a square or a cruciform. The type of domed chamber shape that was used in Timurid cases studies is a square, while the only type used in the mosque of Torbat Jam was the cruciform pattern of domed chamber.

The first Timurid case study (Gohar Shod mosque) has a square domed chamber that was linked to the naves with three narrow vaulted tunnels. The proportion of solid walls exceeds these openings rendering the domed chamber dark and dim. But lack of any blind arch between the south *Ivan* and the domed chamber as well as the identical size of the spaces (domed chamber, Ivan, *mihrab*) make the domed chamber appear integrated and unique, with a wide and bright space, eliminating darkness in the space (see Figure 7.6).

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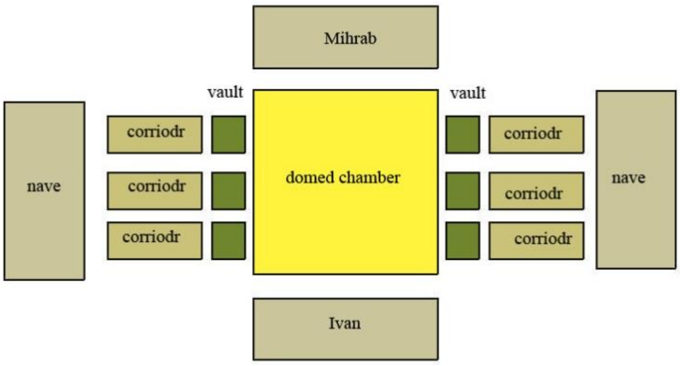


Figure 7.6: Gohar Shad domed chamber's organization and relation with others (Author-2013)

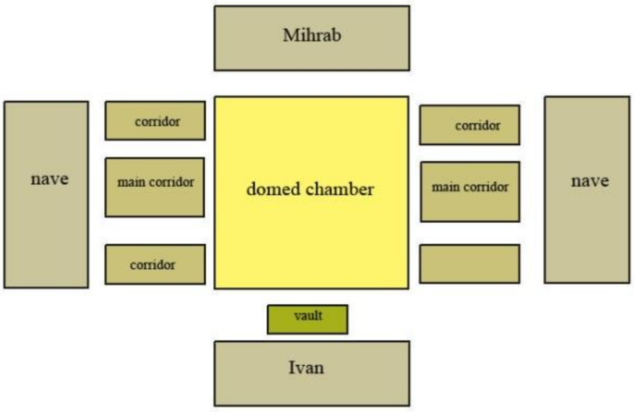


Figure 7.7: Mir Chkhamaq domed chamber‘s organization and relation with others (Author-2013)

The domed chamber of Mir Chakhmaq mosque (second case study) was countiued the form of first case study with some basic changes to the central vaulted tunnels that increased the size and differenced the type of vault. As a matter of fact, this domed chamber contained a pattern that is regarded as a combination of squares and cruciform. It has four small windows in the upper level of the transition tier, and the vaulted tunnels are repeated at the two horizontal levels (see Figure 7.7).

The domed chamber of the Torbat Jam mosque (third case study) was designed based on the famous cruciform-shaped Timurid pattern which is very similar to the rectangular shape. However, the small size of the central section of the domed chamber and the shape can create a more fluid and huge interior concept. Similar to Gohar Shad mosque, the relationship between the south Ivan and the domed chamber (the big network window is delimiter between these two spaces) is highly visible. Four windows are located in the middle part of the central wall behind the transition tier, where the size exceeds the Mir Chakhmagh mosque (see Figure 7.8).

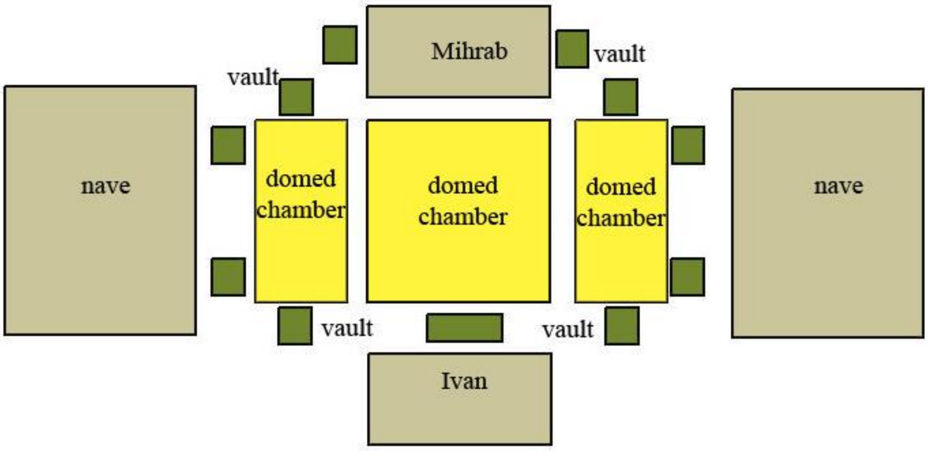


Figure 7.8: Mosque of Torbat Jam domed chamber's organization and relation with others (Author-2013)

7.2.2.2. Combination of Domed chamber, South Ivan& Mihrab

The most powerful combinational patterns between the domed chamber, *qibla Ivan,* and *mihrab* in Persian Islamic architecture has been in development for many centuries; from the Seljuk to Safavid period. The Timurid case studies also followed this combination (refer Figure 7.9).

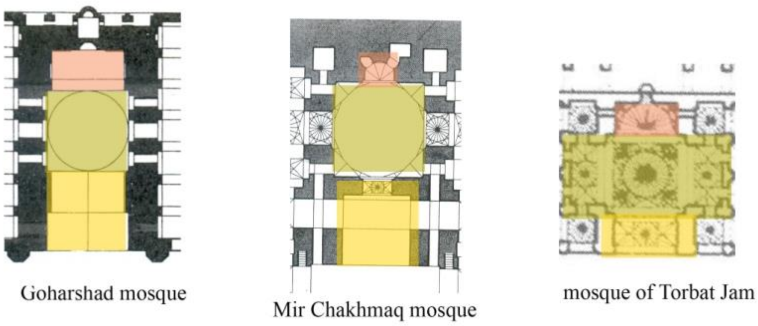


Figure 7.9: Combination of domed chamber, *ivan, mihrab* (Author-2013)

7.2.2.3. Proportions between Domed chamber, Ivan and Mihrab.

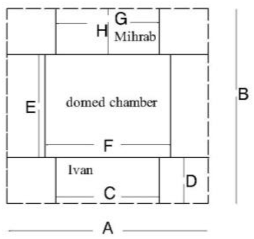
Table D-3 in the Appendix D shows that the geometrical analysis of the Timurid domed chamber is based on the Persian geometrical systems mentioned in section 4.5, proving that many Persian buildings were designed by taking ten geometrical systems into account.

Table 7.8represents the result of geometrical analysis based on Persian geometrical systems. Then, the data were revised in Table 7.9. Finally, these points can be identified in the following form:

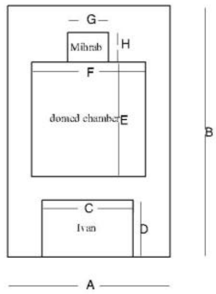
- Generally, the ratio of length-to-width in combination (domed chamber, *Ivan*, *mihrab*) decreased from the first-to-third Timurid case studies.
- The width and length of the domed chamber were studied in Timurid case studies, with the exception of Gohar Shad mosque.
- Three functional elements of Gohar Shad mosque differed due to the approximately identical lengths between these elements, making the combination appear as a unique integration.
- The ratio of length-to-width in the south *Ivan* and *Mihrab* was stabilized despite the decrease in the length and width in the Timurid samples, with the exclusion of the Mosque of Torbat-i-Jam due to the diverse shape pattern of the domed chamber.
- The ratio of length- to- width in south *Ivan* and *Mihrab* has become stable. Even though the ratio of Mosque of Torbat Jam diverse due to different pattern of domed chamber.

Table 7.8: Proportions of combination domed chamber, *mihrab &Ivan* based on geometrical systems (Author-2013)

name of mosque	A	B	C	D	E	F	G	H
Gawhar Shad Mosque	$\sqrt{3}$a	$\sqrt{6}$a	a	a	7/8a	a	7/8a	0.5a
Mir Chaqmaq Mosque	$\sqrt{6}$a	$\sqrt{3}(3+\sqrt{2})$a/2	a	a	$\sqrt{2}$a	$\sqrt{2}$a	$\frac{\sqrt{2a}}{\sqrt{5}}$	$\frac{\sqrt{2a}}{2\sqrt{5}}$
Mosque of Torbat-i-Jam	$\left(\sqrt{2}+\left(\frac{2}{\sqrt{5}}\right)\right)$a	$(\sqrt{3}+\sqrt{2})a$	a	($\sqrt{3}$ -1)a	$\sqrt{2}$a	$\sqrt{2}$a	a	0.5a



Key of Table 7.8 (cruciform



Key of Table 7.8 (square shape)

Table 7.9 : Proportions of combination domed chamber, *mihrab &ivan*" (Author-2013)

name of mosque	combination Ivan, domed chamber& *Mihrab*			Ivan		domed chamber		*Mihrab*	
	width	length	length /width	length	width	length	width	length	width
Gawhar Shad Mosque	1.7A	2.4A	1.4	0.9A	A	A	A	0.9A	0.5A
Mir Chaqmaq Mosque	2.4A	3.8A	1.5	A	A	1.4A	1.4A	0.6A	0.3A
Mosque of Torbat-i-Jam	2.3A	3.1A	1.4	A	0.7A	1.4A	1.4A	A	0.5A

7.2.2.4. Windows

Gohar Shad mosque lacks windows in its domed chamber, but its darkness is not due to its lack of windows. Both Mir Chakhmaq and Torbat Jam mosques have small windows and apertures. In the second case study, four little hollow apertures stood in the upper level of transition section, while in the third mosque, four windows stood (bigger than Mir Chakhmaq mosque's windows) in the transition level (Figure 7.10).

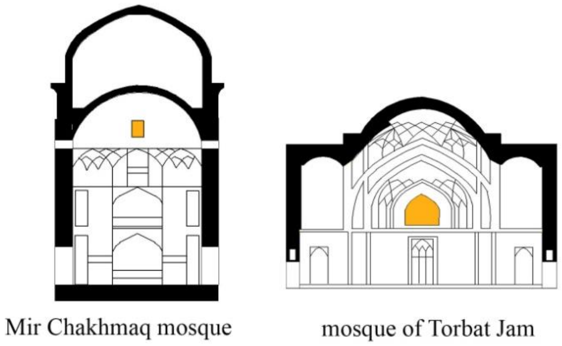


Figure 7.10: Position of domed champers's windows

7.2.2.5. Material

All Timurid case studies were covered with plaster as its dominant material, but other materials were concentrated in special sections or more embellishment (Figure 7.11) such as:

- Ornamentation with dark-blue and gold line, and also blue inscription bands in Gohar Shad mosque
- panel of blue-glazed tile mosaic in Mir Chakhmaq mosque for emphasizing horizontal elements
- Decoration with black line and yellow bands in the mosque of Torbat Jam

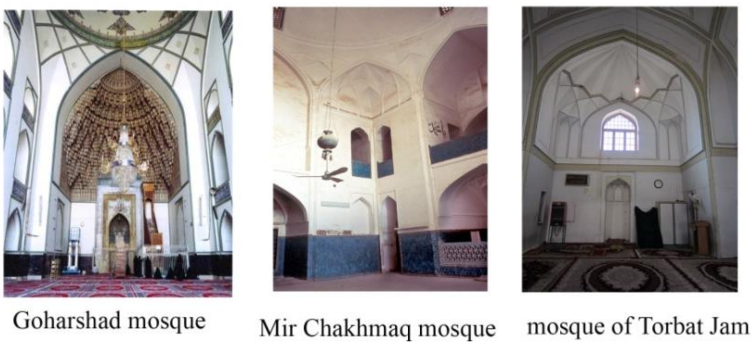


Figure 7.11: Material of domed chambers (Author-2012)

7.2.2.6. Load bearing System or Supporting System

In a domed chamber section, the architectonic concept of load bearing system is a composition of positive and negative arches, which are symmetrically surrounding a central plan. Positive shape patterns are dedicated to the blind arches or solid walls (such as *Mihrab*), whereas the negative shape pattern (which is related to the same pattern of positive shape) exposed the setting of the opening sides surrounding the central plan (refer to Figure 7.12). In all case studies, the positive shape can only be seen in the *Mihrab*, while the other three sides have negative shapes (opening to *Ivan* and naves).

Comparingwith the Timurid case study, the main point that is to be addressed is the decrease in height from the first to the third case studiy. Among Timurid samples, only Mir Chakhmaq mosque was designed based on the Persian typical load bearing system (blind (open) arch-main blind (open) arch, blind (open) arch), concentrating on the center of each side, symmetrical pattern on four sides of the domed chamber, and the division to two horizontal sections (Figure 7.13& Table 7.10). Gohar Shad mosque was designed with three vertical levels, without concentrating at the center of the side and the supporting system of the Torbat Jam mosque, lacking any special ornamentation and focusing only on the Mihrab. In addition, none of the Torbat Jam and Goharshad mosques accounted for any symmetry on four sides, but the side of the entrance and the Mihrab is similar.

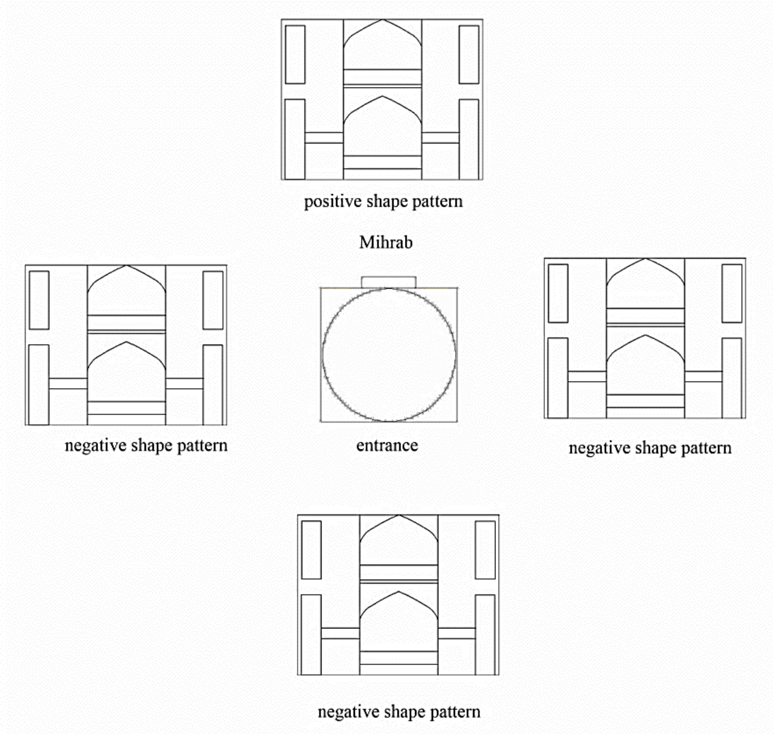


Figure 7.12: Common compositional pattern of load bearing system surrounding domed chambers (Author-2013)

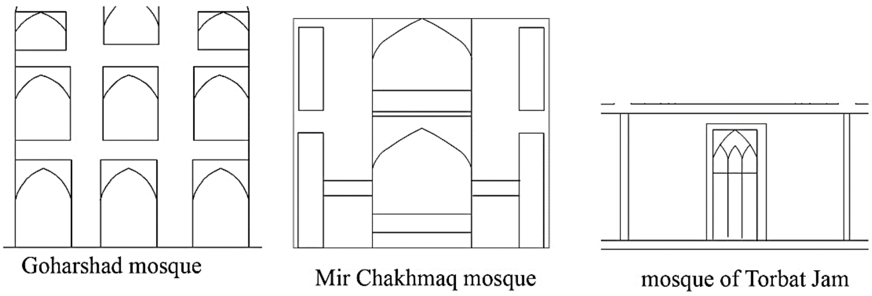


Figure 7.13: Load bearing system of domed chambers (Author-2013)

Table 7.10 : General analysis of domed chambers (Author-2012)

Domed chamber	**shape**	**dimension**			**Elements of internal facade**							**relation**			**opening**	**material**	**Geometrical pattern**	
					Load bearing		Transition section										plan	Façade
		L	W	H	2	3	1	2	3	4	5	*Ivan*	nave	*Mihrab*				
										Timurid								
Gawhar Shad Mosque	Square	20	20	29	1	6				✓		✓	✓	✓	_	plaster	3,4,5,8	1,4,5
Mir Chaqmaq Mosque	Square	12.2	12.2	18.3	5	14	✓			✓		✓	✓	✓	4		1,3,4,5	1
Mosque of Torbat-i-Jam	cross-shaped	10	10	13.5	1	7			✓	✓		✓	✓	✓	4		2,4,8	1,3,4

load bearing system
1.blind arcade
2.open arcade

transition system
1.squinch
2.pendative
3.recumbent arch
4.arch-net (*squinch*-net)
5.muqarnas

7.2.2.7. Transition System

According to Liza Gilombek (1988, p. 103), transition systems can be classified into two main categories: functional (*squnich*, recumbent arches ,*pendentives*) and nonfunctional (arch-net ,*mugarnas*). Nonfunctional transition systems can be used together with functional ones.

In the Timurid case studies, the first and second samples used popular Persian transitional system (*squinch*); in Mir Chakhmag mosque, four *squinches* and four main blind arches were integrated and formed a unique combination (see Figure 7.14& Table 7.10).

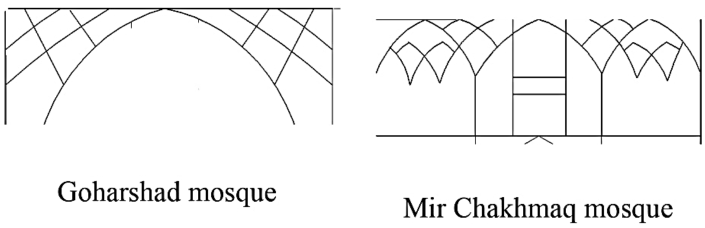


Figure 7.14: Transition tier of domed chambers (Author-

7.2.2.8. Geometrical System of Domed Chamber

Table 7.10 and Figure 7.15 show the usage of Persian geometrical systems in both façade and plan of the internal domed chamber. The information was derived from Table D-3 in the Appendix D.

- More similarity can be seen in the plans rather than the internal façade.
- In the plan of the Timurid case studies, the most useful systems were in the order of three, four, and one.
- In the internal façade, none of Persian geometrical systems was repeated in all Timurid samples, with the useful ones being determined to be one and four.

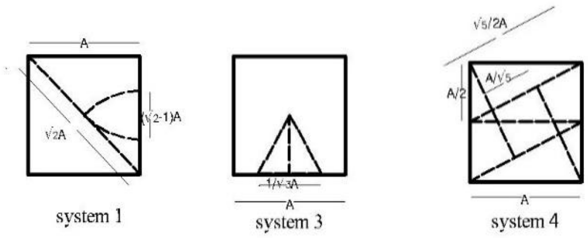


Figure 7.15 Table: Most useful geometrical systems in domed chambers(Golombek et al., 1988)

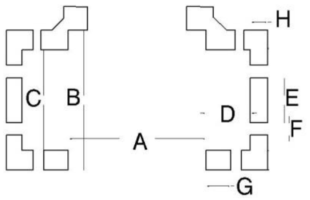
7.2.2.9. Horizontal Proportion of Domed Chamber

Table D-3 in the Appendix D displays the geometrical analysis of Timurid domed chamber based on the Persian geometrical system. The results were shown in Table 7.11, and then revised , summarized in Table 7.12.

- Gohar Shad mosque was a diverse length proportion to the other, due to the wide *Ivan* and *Mihrab.*
- In Mir Chakhmaq mosque, all main openings, including the*Mihrab*, entrance, and main vaulted tunnel have the same length, but in Gohar Shad mosque, the length of the *Ivan* is equal to the Mihrab, with all vaulted tunnels being either similar or smaller.
- The thickness of the walls decreased from the first to the third Timurid case studies.

Table 7.11: proportions of domed chamber's plan based on Persian geometrical patterns (Author-2013)

name of mosque	A	B	C	D	E	F	G	H
Gawhar Shad Mosque	a	a	7a/8	a/4	a/4	7a/8	a/8	$\frac{\sqrt{2}a}{4}$
Mir Chaqmaq Mosque	a	a	$\frac{a}{\sqrt{5}}$	$\frac{a}{\sqrt{5}}$	$\frac{(\sqrt{5}(2-\sqrt{2})a-a)}{2\sqrt{5}}$	$\frac{a}{\sqrt{5}}$	$\frac{\sqrt{2}a}{8}$	$\frac{\sqrt{2}a}{4}$
Mosque of Torbat-i-Jam	$\sqrt{2a}$	$\sqrt{2a}$	a	$\frac{a}{\sqrt{5}}$	$\frac{a}{\sqrt{5}}$	$\frac{(\sqrt{5}-2)a}{\sqrt{5}}$	$\frac{2a-(\sqrt{5}(\sqrt{2}-1)a)}{2\sqrt{5}}$	$\frac{(\sqrt{2}-1)a}{\sqrt{5}}$



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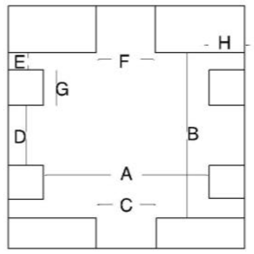


Key of Table 7.11 (square shape)

Table 7.12: Proportions of horizontal dimension of domed chambers (Author-2013)

name of mosque	length	width	entrance	main vaulted tunnel	secondary vaulted tunnel	*Mihrab*	length of wall between corridors	thickness
Gawhar Shad Mosque	A	A	0.9A	0.25A	0.25A	0.9A	0.12A	0.35A
Mir Chaqmaq Mosque	A	A	0.45A	0.45A	0.1A	0.45A	0.2A	0.35A
Mosque of Torbat-i-Jam	1.4A	1.4A	A	0.45A	0.45A	0.1A	0.2A	0.2A

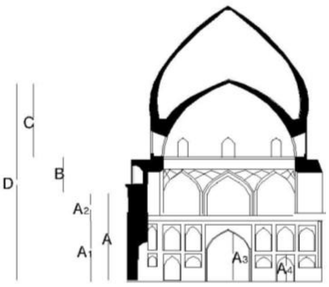
7.2.2.10. Vertical Proportion of Domed Chamber (Internal Façade)

As similar horizontal proportions, the outcomes of Table D-3 in the appendix D were firstly proposed in Table 7.13, and were refined in Table 7.14.

- Generally, the overall height of the domed chamber decreased from the first to the third case studies, with the early Timurid case studies having taller and smaller domed chambers.
- The height of the lead bearing system decreased in the Timurid period from the first to the third case studies.
- The exclusion of the mosque of Torbat Jam, which is composed of one shell dome and height of the dome, differed from the others; height of internal dome in other case studies became steady, and the height of transition system was not greatly altered.
- The height of the main and secondary vaulted tunnels is equal in all Timurid samples.

Table 4.13: Proportions of domed chamber‘s façade based on Persian geometrical patterns (Author-2013)

name of mosque	A	A_1	A_2	A_3	A_4	B	C	D
Gawhar Shad Mosque	$\frac{2a}{\sqrt{5}}$	-	-	$\frac{(\sqrt{2}+2)a}{8}$	$\frac{(\sqrt{2}+2)a}{8}$	$\left(\frac{(\sqrt{2}+2)}{2}\right)-\frac{2a}{\sqrt{5}}a$	a/2	$\frac{(\sqrt{2}+2)a}{2}$
Mir Chaqmaq Mosque	$\frac{2a}{\sqrt{5}}$	$\frac{a}{\sqrt{5}}$	$\frac{a}{\sqrt{5}}$	$\frac{a}{\sqrt{5}}$	$\frac{a}{\sqrt{5}}$	$\frac{\sqrt{2}a}{2\sqrt{5}}$	a/2	3a/2
Mosque of Torbat-i-Jam	$\frac{(\sqrt{5}-1)a}{2}$	$\frac{(\sqrt{5}-1)a}{2}$	–	a/2	$\frac{a}{\sqrt{5}}$	$\frac{2(\sqrt{5}-1)a-\sqrt{2}a}{4}$	$\frac{a}{2\sqrt{2}}$	$\frac{(\sqrt{15}+1)a}{\sqrt{15}}$



Key of Table 7.13

Height of internal domed chamber= height of load bearing system+ transition system+ height of internal dome

Table 7.14: Proportions of vertical dimension of domed chambers (Author-2013)

name of mosque	load bearing					transition tier	internal dome	domed chamber
	load bearing	lower section	upper section	main corridor	secondary corridor			
Gawhar Shad Mosque	0.9A	-	-	0.4A	0.4A	0.3 A	0.5A	1.7A
Mir Chaqmaq Mosque	0.75A	0.45A	0.45A	0.45A	0.45A	0.25 A	0.5A	1.5A
Mosque of Torbat-i-Jam	0.6A	0.6A	-	0. 5A	0.45A	0.25 A	0.35A	1.2A

7.2.3. Double dome

After the innovation of continuous double dome during the Illkhanid era, the usage of double dome was continued in Timurid architecture, albeit with a novel face; discontinuous double dome that can be identified as one of the most popular structural features of this period. Timurid architecture is remarkable for the colossal scale of most buildings, so that high domes with two separate shells can increase the height and diameter of the domes. Among the Timurid case studies, the mosque of Torbat Jam neglected this principle, because it only has one shell dome located on top of its cruciform-shaped sanctuary (see Table 7.15, Figure 7.16).

Table 7.15: General analysis of double dome (Author-2012)

Name of mosque	Supporting system	Transition tier	C**	Type of internal shell		Type of external shell		drum	material	
				type	H*	type	H*	type	outer	inner
Gawhar Shad Mosque	Square with bearing wall	Squinch +arch-net	62	Semi circular	29	Bulbous	54	Cylinder	Fiancé Mosaic	Plaster
Mir Chaqmaq Mosque			38	circular	18.3	pointed	27			
Mosque of Torbat-i-Jam	-	-	-	-	-	-	-	-	-	-

MirChkhmaq mosque

Gohar Shad mosque

Figure 7.16: Domes of Timuird case studies (Author-2012)

7.2.3.1. External Shell

This is what it appears to be from the outside of dome buildings, and it is the only architectural item that was conceptually found synonymously during several Islamic epochs. Figure presents a common geometric prototype for pointed and bulbous dome. There are two different approaches for covering the external shell. The first case study (Gohar Shad mosque) used a bulbous (onion) shell, which is an innovation in Timurid architecture, and was developed in later Persian periods and out of the territory of Persia. Secondly, the latter case study (Mir Chakhmaq mosque) followed the old manner for the external shell, and used a pointed shell (see Figure).

7.2.3.2. Proportions of External Shell

Comparing the proportion of external domes (see Table 7.16and Figure 7.19) showed that the bulbous shell domes are higher than the pointed shell dome among the samples.

Table 7.16: Proportions of external shell of double domes (Author-2013)

Name of mosque	Pointed dome					Bulbous dome					
	L_1	L_2	H_2	angel	H	L_1	H_1	L_2	H_2	L_3	H
Gawhar Shad Mosque						0.3a	0.15a	1.5a	0.75a	0.1a	0.75a
Mir Chaqmaq Mosque	0.5a	0.25a	0.31a	25°	0.4a						
Mosque of Torbat-i-Jam	-	-	-	-	-	-	-	-	-	-	-

7.2.3.3. Internal shell

The covered internal domed chamber has simple geometric formation compared to the external shell, and it fully conformed to the external shell for transferring the forces from the upper component to the lower ones. The most common prototype for internal shell formations was determined as semicircular, pointed, and ribbed pointed. Mir Chakhmaq is semicircular (saucer shape), but Gohar Shad mosque is slightly pointed (see Figure 7.18).

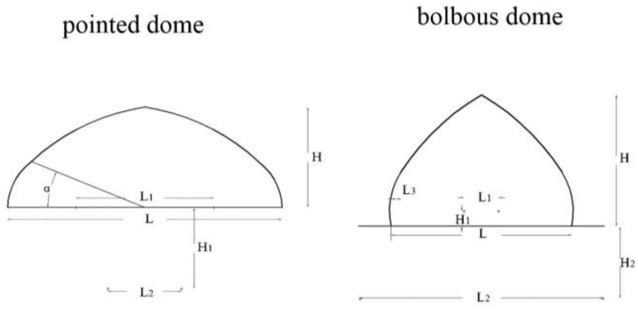
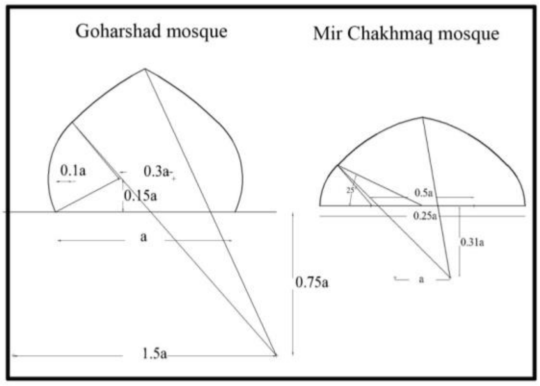


Figure 7.17: Common geometric prototype for pointed and bulbous dome(Ashkan & Ahmad, 2010)



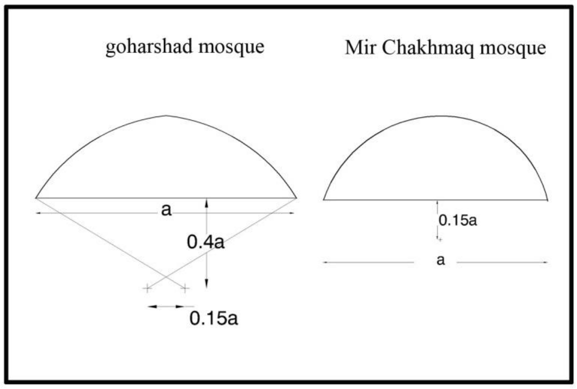


Figure 7.19: Type and dimension of external shell of double domes (Author-

Figure 7.18: Type and dimension of internal shell of double dome (Author-

Transition tier and **load bearing system** were described in domed chamber and *squinch* elements.

7.2.3.4. Drum

Drums are often cylindrical in form, and are where the external shell rests upon. Moreover, it is the only component of the dome to have opening windows, which provides lighting for the internal domed chamber. All of the Timurid case studies followed the cylindrical form.

7.2.3.5. Material

All of the samples from the Timurid period have been covered by washed plaster internally, and mosaic faience externally (refer to Figure).

7.2.3.6. Thickness

The thickness of both the internal and external shells was gradually reduced from the base to the top of the dome in Timurid case studies.

7.2.4. Squinch

As it was mentioned in 4.4.4, different types of *squinch* can be categorized into four types (Figure 7.20 & Table 7.17):

- Simplest type: a beam across the corner with revetment of the arch-net or *muqarnas*
- a cellular console *squinch*
- semi-domes or groined vaults
- nested or stepped arch

With the notable exception of the mosque of Torbat Jam, which utilized a recumbent arch, *squinch* was used in two other Timurid case studies. The earliest Timurid case studies have the simple form of *squinch* and a beam across the corner, with plaster revetment of the arch-net, while Mir Chakhmaq mosque used the typical and widespread form of Timurid *squinch* - groined vaults- with additional ornamentation on the inside (*squinch*-net or arch-net).

Table 7.17 : General analysis of *squinch* (Author-2013)

Name of mosque	type	material	position		
			Ivan	dome	entrance
Gawhar Shad Mosque	A beam across the corner with plaster revetment of arch-net	Plaster	-	✓	-
Mir Chaqmaq Mosque	Groined vaults with revetment of arch-net	Plaster	-	✓	-

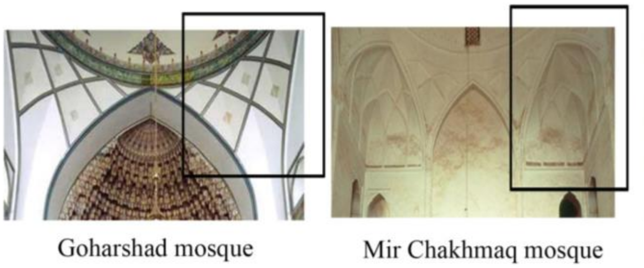


Figure 7.20: material and type of *squinchs* (Author-

7.2.5. Pointed arch

As mentioned in 4.4.6, compared to circular and simple pointed arch (like Gothic arch), pointed arches within three or four centers have become the most popular type of arches in Persian Islamic architecture.

With regards to Table 7.18, in the Timurid era, the best arch type for covering a wide and high space was type 3-1, called "*Panj-O Haft kond*" in Persian architecture. Pirnia(1991, pp. 15-42) mentioned in his book that "arches and vaults (*chefthavataghha*)" :*Panj-O Haft* is one of the most resistant Persian pointed arch, making it appropriate for wide spaces in Persian mosques, such as domed chamber, south *Ivan*, and the entrance (refer to Figure 7.22).

Contrasting type 3-1, type 4-1, or "*She-E Bakhshi-E Tond*" (in Persian architectural manuscript) was used for small and low space as non-load bearing arches, and it is suitable only for ornamentation purpose and not for structural reasons. It can be seen in the courtyard façade and secondary *Ivans* (outside) of Timurid case studies (refer to Figure 7.21). Types 6-1 and 6-2 were called "*Shabdari-E Tond*" and "*Shabdari-E Kond*", respectively; and were utilized similarly for both inside and outside for covering small spaces, such as *Mihrab (*Figure7.23 & Figure7.24).

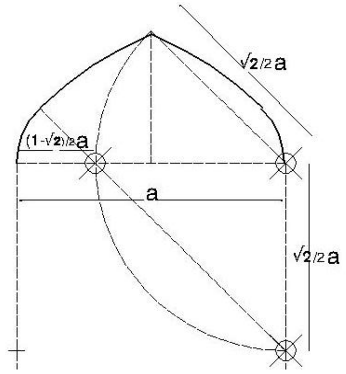


Figure 7.22: Arch type 3-1(Panj-O Haft) (Pirnia, 1991)

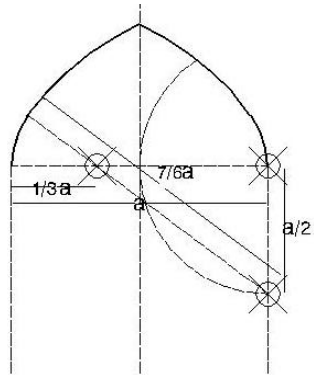


Figure 7.21: Arch type4-1 (She-E Bakhshi-E Tond)(Pirnia, 1991)

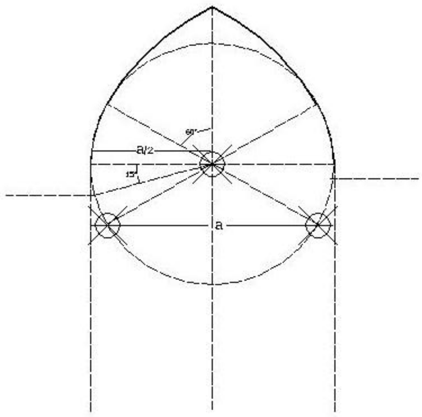


Figure 7.24: Archtype6-1(Shabdari-E Tond) (Pirnia, 1991)

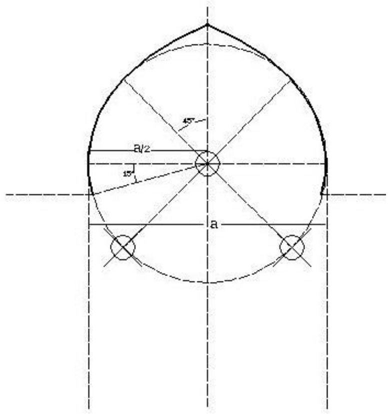


Figure 7.23: Arch type6-2(Shabdari-E Kond) (Pirnia, 1991)

Table 7.18: General analysis of pointed arch (Author-2013)

	Name of mosque	type					Position								
							Inside				Outside				
		3-1	**3-2**	**4-1**	**6-1**	**6-1**	Domed chamber	*Mihrab*	nave	corridors	South *Ivan*	North *Ivan*	East & west Ivan	Court yard	Entrance
1	Gawhar Shad Mosque	✓									✗				
2		✓					✗								
3				✓										✗	
4				✓								✗			
5				✓									✗		
6	Mir Chaqmaq Mosque		✓				✗								
7			✓								✗				
8			✓												✗
9				✓								✗			
10				✓									✗		
11						✓		✗							
12						✓			✗						
13	Mosque of Torbat Jam	✓					✗								
14					✓			✗							
15						✓					✗				
16						✓						✗			
17						✓								✗	

7.2.6. Main findings of Persian elements in Timuird mosque

(CS1-Goharshad Mosque, CS2-Mir Chakhmaq Mosque, CS3-Mosque of Torbat Jam)

Ivan

- Design based on the most popular Persian mosque type- four *Ivans* mosques (CS1, CS2).
- Design based on one or two *ivans* mosque (CS3).
- South *Ivan* as the main *Ivan* was bigger and deeper than the other *Ivans* (CS1, CS2).
- South Ivan was only related to domed chamber (CS1, CS3).
- All Ivans are located in the center of each side (all CSs) and in a line behind the façade (except south Ivan of CS1).
- South Ivan and the others were related to all spaces in and around themselves (CS2).
- The typical horizon form of an Ivan is rectangle in Persian mosques (all CSs).
- Vaulted tunnels encompass *ivans*(all CSs), and vault of *Ivans* have additional plaster revetment of squinch-net (arch-net) (CS3).
- The dominant material was mosaic faience, chiefly for external parts of *Ivans* (CS1, CS2), plaster (CS2, CS3), and mosaic fiancé (CS1) for the internal parts.
- Typical form of south *Ivans* comprised of " a band throughout *Ivan,* a spandrel, a plinth, open arch" (CS2, CS3), or the other type is" a band throughout *Ivan*, a spandrel, a plinth, open arch, inscription frieze, and two big minarets "which extended to ground were inserted to south *Ivan*(CS1)".
- The system of structure was vaulted tunnels (all CSs), however, the revetment of squinch net (arch-net) was determined to be covered vault in mosques (CS3).

- Mosques were designed without any wall between the south *Ivan* and domed chamber (CS1, CS3), or open vaults were connected between the south *Ivan* and the domed chamber (CS2).
- Other *Ivans* are similar to the typical form of south *Ivan*, including a band throughout the *Ivan*, a spandrel, a plinth, and open arches (all CSs). (CS3) had additional decorations in the form of *squinch* net.
- In the façade, the most practical patterns are one, two, five, and eight (all CSs).
- Patterns three and four are most useful patterns in plans (all CSs).
- The ratio of length-to-width and height is similar (CS2, CS3), and in Goharshad mosque is larger due to the insertion minaret and size of courtyard (CS1).
- Ratio of length-to-height is similar (all CSs).
- Among these minor demotions, vertical elements are more similar in proportion rather than the horizontal elements, as other functional sections such as domed chamber and naves influence the second group. Among the vertical elements of the *Ivan's* screen, the length of the opening to the backspace and the height of the*Ivan* (from the ground to top of spandrel) are similar (all CSs).
- Similar to the south *Ivan*, patterns one,two,five, and eight are the most used patterns in the façade of the north *Ivan* (the same east and west *Ivans*), while patterns one, three, and four can be seen in the plans (all CSs).
- In comparison to the south *Ivan*, other *Ivans* of Timurid samples are more of a match in the ratio of length-to-width and height, with the exclusion of the north Ivan of Mir Chakhmaq (all CSs).

Domed chamber

- Timurid mosques have diversity in the form of domed chamber; square (CS1, CS2), and cruciform (CS3).

- Persian Powerful combinational patterns (*Ivan*, domed chamber, *Mihrab*) (all CSs).
- Relations of domed chamber to nave, with three vaulted tunnels on both sides (all CSs).
- The central vaulted tunnels between the naves and domed chamber increases the size and difference of the type of vaults (SC2).
- High relation between the domed chamber and the south *Ivan* and *Mihrab* (CS2, CS3).
- Positive shape in the domed chamber can only be seen in the*Mihrab*, whilethe other three sides have negative shapes (opening to the *Ivan* and naves) (all CSs).
- Persian typical load bearing system (blind (open), arch-main blind (open) arch, blind (open) arch), with the concentration at the center of each side, and symmetrical pattern at four sides of the domed chamber, with a division to two horizontal sections (CS2).
- The usage of popular Persian transitional system – *squinch* with revetment of arch-net (CS1, CS2), and recumbent arch (CS3).
- Using four small windows and apertures in the upper level or the same level of domed chamber (CS2, CS3).
- Covering domed chamber with plaster as a dominant material, but utilizing other materials as a concentration in special section or more embellishment (all CSs).
- Using Persian geometrical patterns three and four in the plans (all CSs), and 1 in CS2&CS3.
- Using Persian geometrical patterns one and four in the façade (all CSs).
- A decrease in the ratio of length to width of the combination (domed chamber, *ivan*, *mihrab*) from the first to fourth Persian case studies (all CSs).

- The proportion of the domed chamber's length and width becoming steady (CS2, CS3).
- The ratio of length- to -width for *Ivan* and *Mihrab* becoming stable (all CSs).
- Similar lengths of the entire main opening of the domed chamber, including *Mihrab*, the entrance, and main vaulted tunnel (CS2).
- The decrease of the domed chamber's thickness from the first to third case studies (all CSs).
- The decrease of the domed chamber's height from the first to third case studies (all CSs).
- The reduction of the load bearing's height and internal height from the first to the third case studies (all CSs).
- The height of the internal dome becoming steady (CS1, CS2), and the height of the transition system not undergoing much changes (all CSs).

Double dome

- Using discontinuous double domes (CS1,CS2)
- Different approaches for covering external shells: bulbous (onion) shell that is MKinnovation (CS1), and pointed shell as an old manner for an external shell (CS2).
- Simple geometric formation in the internal shell of domed chamber, with semicircular (saucer shape) (CS2) and slightly pointed (CS1) shapes.
- The bulbous shell dome (CS1) is higher than the pointed shell one (CS2).
- Drum is often cylindrical in form where the external shell rests on (CS1, CS2).
- Double domes of the mosques, covered by washed plaster internally, and mosaic fiancé externally (CS1, CS2).
- A gradual decrease in the thicknesses of both internal and external shells from the base to the top of dome (CS1, CS2).

Squinch

- Using the first type of a*squinch*, which isa beam across the corner with plaster revetment of arch-net (CS1), and also typical and wide spread type of Timurid *squinch* - groined vaults (CS2).
- Using additional ornamentation (*squinch* -net or arch-net) inside the *squinch* (CS1, CS2).

Pointed arch

- The best arch type for covering a wide and high space was type 3-1 and 3-2, called “Panj-O Haft-Tond” and “Panj-O Haft-Kond”. It is appropriate for wide spaces in Persian mosques, such as the domed chamber, the south *Ivan*, and entrance (CS1, CS2, and CS3).
- Type 4-1 or “Se-E Bakhshi-E Tond” was used for small and low space as a non-load bearing arch, and it has an ornamental purpose rather than a structural one. It can be seen in the courtyard façade and secondary *Ivans* (outside) (CS1.CS2).
- Type 6-1 and 6-2, called “Shabdari-E Tond” and “Shabdari-E Kond”, respectively, were utilized as the same type both inside and outside to cover small spaces such as *Mihrabs* (CS2, CS3).

Phase two: comparison between Timurid and Safavid case studies with Mughal case studies (early and high phases)

7.3. Phase Two-Level One: The Comparison between Timurid and Early Mughal Case Studies Based on Second Proposition

This section is level one of phase two of results and discussion, which described the results of second proposition of Timurid architectural influence in Mughal buildings as direct influence. This level focuses in comparison between Timurid and early Mughal case studies.

7.3.1.Ivan

One of the fundamental characteristic of Mughal mosques is multiplicity access from two or three sides, unlike the Timuird mosques. Each entrance link and merge with an *Ivan*, consequently it can be composed the gateway complex. Fatehpur sikiri mosque has three *ivans* instead of typical four *ivans* in Timurid mosque. Because the north *Ivan* was replaced by the tomb. Among these three *ivans*, the south and west were connected to gateways, so that the size is differenced with less depth.

7.3.1.1. Relation of Ivans

The west *Ivan* followed the most useful pattern in Timurid case studies that a *Ivan* connected to all behind spaces both internally and externally. Even though the slight alteration with Timurid pattern can be seen. The *qibla* side of *Ivan* has three vault tunnels due to complete symmetry with the domed chamber (refer to Figure , a).

The relational of pattern that specified to big south *Ivan* that include three smaller *ivans* that merged with big vestibule and Boland Darwasa gateway as majestic part of mosque (refer to Figure 7.25.b). The relational pattern of east *Ivan* (see Figure 7.25, c) is totally similar to second prevalent pattern in Timurid *ivans* (see Figure 7.3) that each *ivan* only link to one inside space and courtyard.

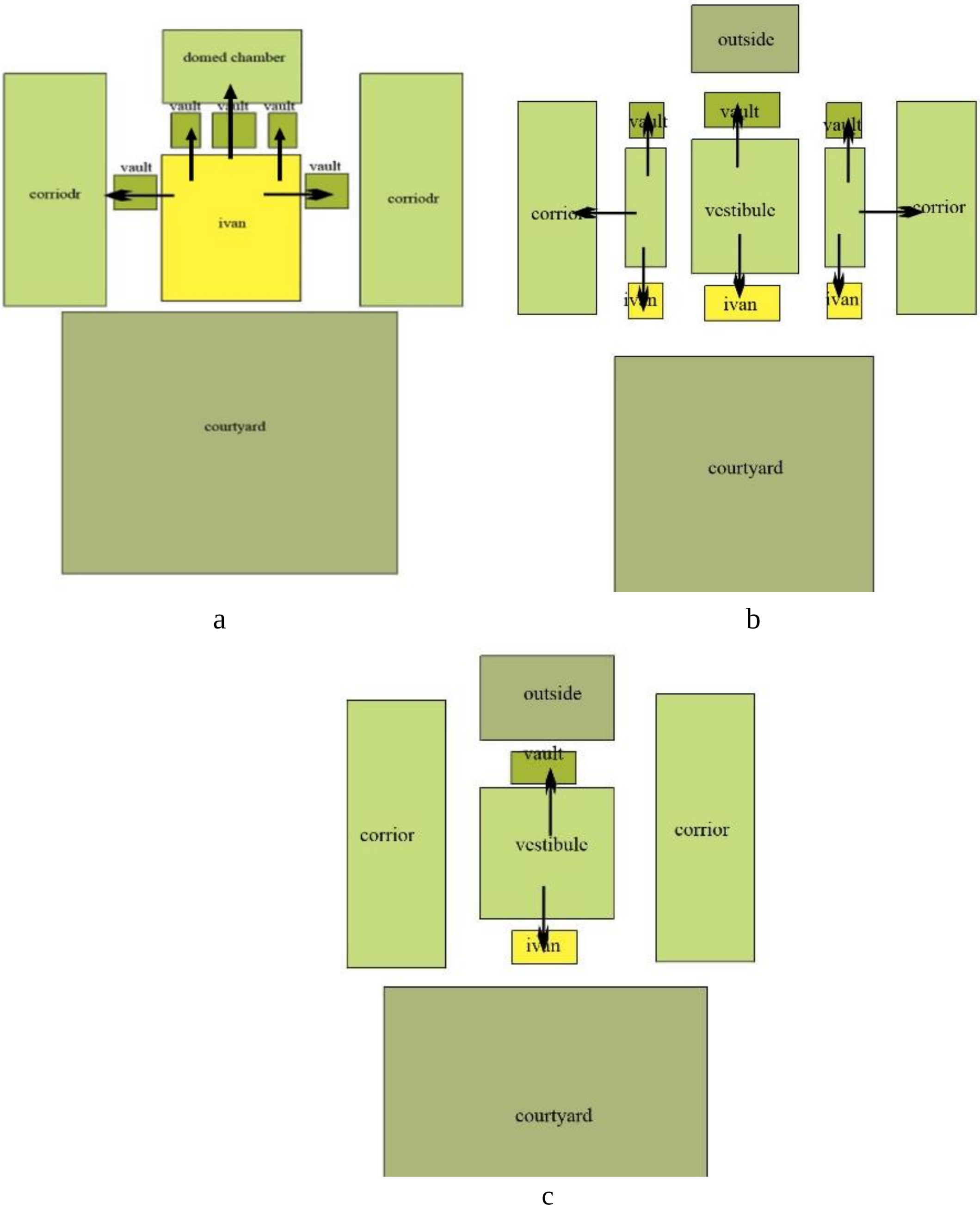


Figure 7.25: Patterns of *ivans*'s relation with other spaces (Author-2013)

like the Timurid case studies, the *ivans* of Fatehpur sikiri mosque as early Mughal case study have rectangle form, but the south and east ones are rectangular with high length and low width , because of combination *ivans* with gateways.

7.3.1.2. Structure of Ceiling

The west *Ivan* as biggest one was covered by semi dome and has revetment of *muqarnas*. The south and west *ivans* were covered by vault tunnel with small depth. These two *ivans* had similar structure with Timurid case studies (see Figure 6.80).

7.3.1.3. Material

The chief material for all *ivans* are red sand stone that ornamented by yellow sand stone and mosaic inlay work. So that the material of Ftehpur sikri mosque is different with Timurid case studies, only in using mosaic faience (see Figure 6.80).

7.3.1.4. Elements of Ivan's Facades

***Gibla Ivan* (west *Ivan*):** the element of façade in Fatehpur sikir mosque comprise: open arch, spandrel, band throughout *Ivan*, inscription frieze above main arch, parapet, *chatris* and mini minaret. Exclusion *chatris* (as local Indian elements) and parapet, the other elements is approximately similar to Timurid architecture especially south (*gibla) Ivan* of Goharshad mosque. Some alteration can be recognized such as: decrease the size of minaret and convert to mini minaret as ornamental not structural, increase the number of open arch (three), omission of plinth (refer to Figure 7.26)

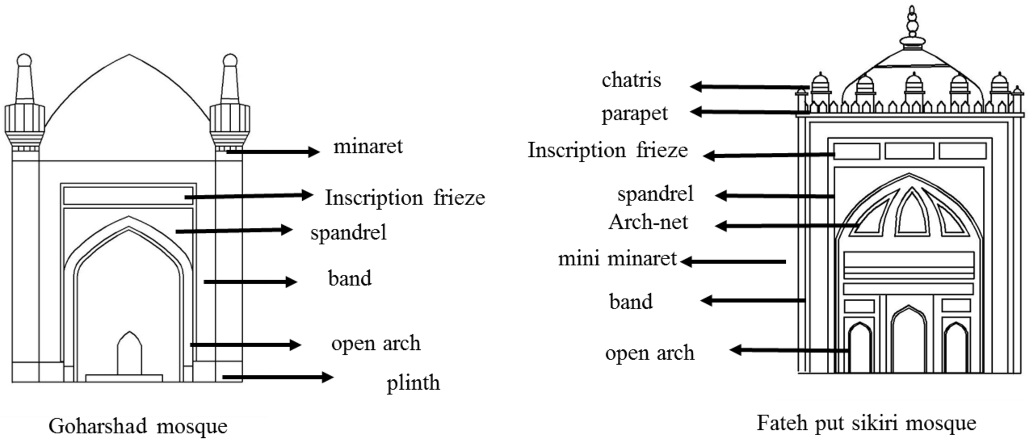


Figure 7.26: Elements of façade in *gibal Ivan* (Author-2013)

East and south *ivans*: these are similar to west *ivan* and they were followed the general combination of Timurid *ivan* pattern with some changes. Unlike the west *ivan* of Fatehpur sikiri mosque, the east one has only one big open arch and the south one has three big open arch , due to combination with the majestic Boland Darwza gateway . In addition, the using blind arch (for both south and east one) and division inscription frieze above central arch of south *Ivan* are the alteration in comparison with west *ivan* (refer to Figure 6.80).

7.3.1.5. Geometrical System and Proportions of Ivans

With regard to Table D-4(in the Appendix D- geometrical analysis of early Mughal mosque), Table 7.19 and with comparison them with Table 7.1 (Persian geometrical systems in Timurid *ivans*), This points can be viewed:

More similarity with *ivans* of Timurid mosques can be seen in the plan especially with west *Ivan* in Fatehpur sikiri mosque and (the analogous geometrical systems are three and four). In the façade, only geometrical systems two and five were used in both Timurid and early Mughal samples (Figure 0.27). Moreover, the proportion of *ivans* that was based on geometrical systems (refer to Table XI), shows in Table and the revised results displays in Table 7.20 .

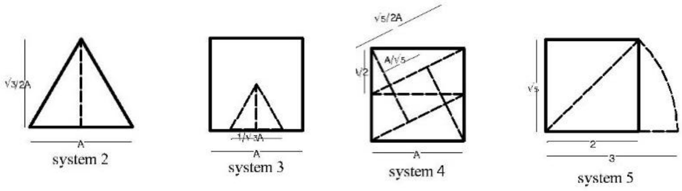


Figure 0.1 :Most useful geometrical systems in *ivans*(Golombek et al., 1988)

With comparing these results and proportions with Timurid *ivans* (refer to Table 7.3 ,Table 7.5 & Figure 7.27), it can be concluded that The proportions of west ivan in Fatehpur Sikiri mosque in more similar to south *ivan* of Mir Chakhaq mosque. Only the former mosque has higher height. In the other *ivans* (south and east), the proportions can be matched with none of Timurid case studies, due to combination with gateway.

Table 7.19: Proportions of *ivans* based on geometrical systems (Author-2013)

name of *ivan*	length	width	height	height of minarets	height of dome
west *ivan*	$\sqrt{3}\,a$	$\sqrt{3}/\sqrt{5}\,a$	$\sqrt{3}\,a(1+\sqrt{2}/8)$	-	$\sqrt{3}\,a(1+1/2)$
East *ivan*	$\sqrt{3}\,a$	-	$\sqrt{3/5}\,a$+$\sqrt{3}a$	-	-
South *ivan*	7a	-	3a	-	-

Table 7.20: Proportions of *ivans* (Author-2013)

name of ivan	length	width	height	height of minarets	height of dome
west ivan	A	0.7A	1.2A	-	1.5A
East *ivan*	A	-	1.4A	-	-
South *ivan*	2.3A	-	A	-	-

7.3.2. Domed Chamber

The domed chamber as main part of prayer hall is located in west site in all Mughal mosques in contrast to Timurid mosques. Due to the direction of Mecca is the west in India and in the south in the Persia.

7.3.2.1. Form

The form of domed chamber like two Timurid case studies (Goharshad mosque and Mir Chakhmaq mosques) is square.

7.3.2.2. Relations of Domed Chamber

The Fatehpur sikri mosque was designed according to the square with three vault tunnels in the all sides that connected domed chamber to its behind prayer halls , *mihrab* and *ivan* similar to Goharshad mosque and Mir chakhmaq mosques(see Figure ,Figure , Figure 7.28). However, the central tunnels are bigger and higher like Mir chakhmaq mosque .unlike the Timurid one

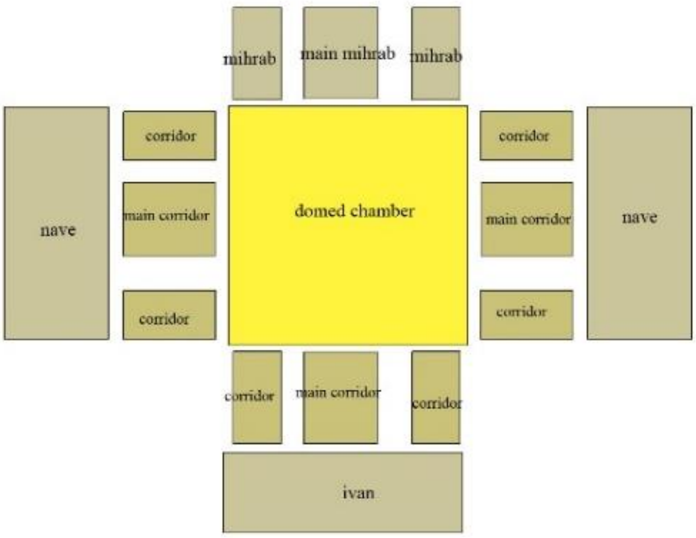


Figure 7.28: Organization of domed chamber in Fatehpur sikri mosque (Author-2013)

s, this manner repeated in the west (*qibla* side) and east (entrance side), consequently it can be seen three *mihrabs* in the domed chamber (the multiplicity of *mihrabs* is one the characteristic of Fatepur sikir mosque).

7.3.2.3. Combination of Domed Chamber, Ivan & Mihrab

The famous and powerful Timurid combination of *Ivan* and domed chamber was continued in the Ftaehpur sikri mosque as early Mughal architecture (see figure 6.89).

7.3.2.4. Proportions between Domed chamber, Ivan and Mihrab

Table D-4 in the Appendix D represents the geometrical analysis of Fatehpur sikiri mosque based on Persian geometrical systems. Then the results shows in Table 7.21 and revises in Table 7.22 . Final results must be compared with Timurid case studies (refer to Table 7.9) . These results can be recognized as below:

- The overall ratio of length- to- width for combination of domed chamber, *gibla Ivan*, *mihrab* is like Timurid case studies, but the separate proportions for length and width are similar only to Gohar shad mosque.
- In comparison to Timurid case studies, Ftarehpur sikiri mosque has less depth of *Ivan* and smaller *mihrab* (due to the multiplicity of *mihrabs* in domed chamber).

Table 7.21: Proportions between domed chamber, *mihrab*, *qibla Ivan* based on geometrical systems (Author-2013)

name of mosque	A	B	C	D	E	F	G	H
Fatehpur sikri mosque	$\sqrt{3}\left(1+\frac{1}{\sqrt{5}}\right)a$	$\sqrt{3}a$	a	$\frac{\sqrt{3}}{5}a$	$\frac{\sqrt{15}a}{1+\sqrt{5}}$	$\frac{\sqrt{15}a}{1+\sqrt{5}}$	¼ a	1/8 a

Table 7.22: Proportions between domed chamber, *mihrab, qibla Ivan* (Author-2013)

name of mosque	combination Ivan+ domed chamber+ Mihrab			Ivan		domed chamber		Mihrab	
	width	width	length /width	length	width	length	width	length	width
Fatehpur sikri mosque	2.5A	1.7A	1.5	A	0.8A	1.2A	1.2A	0.25A	0.12A

7.3.2.5. Windows

Like to two late Timurid case studies (Mir chakhmaq and Torbat jam mosques) (refer to Figure 7.10, Figure 7.29), Fatehpur sikri mosque has four windows in the domed chamber. On the other hand, the size and position of windows is similar to Torbat jam mosque in transition sections.

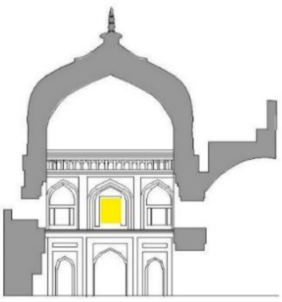


Figure 7.29: Position of windows in domed chamber (Author-2013)

7.3.2.6. Material

The main material of Fatehpur sikir mosques is red sand stone unlike Timurid case studies that used plaster, but the other material as revetment is similar especially to Goharshad mosque. Fatehpur Sikir mosques was ornamented with glazed tile, covered ,and painted inscription (see 6.80).

7.3.2.7. Load Bearing System

Analogous Mir chakhmaq mosque, Fatehpur Sikri mosque followed the typical pattern of domed chamber that comprise :open arch(blind) arch, main open(blind) arch ,open(blind) arch , with concentration the central arch in the each sides and symmetrical pattern in four sides . However, the difference is that Mir chakhmaq mosque has two identical horizontal levels and Fateh pursikiri has one horizontal level in its load bearing system (refer Figure 7.30).

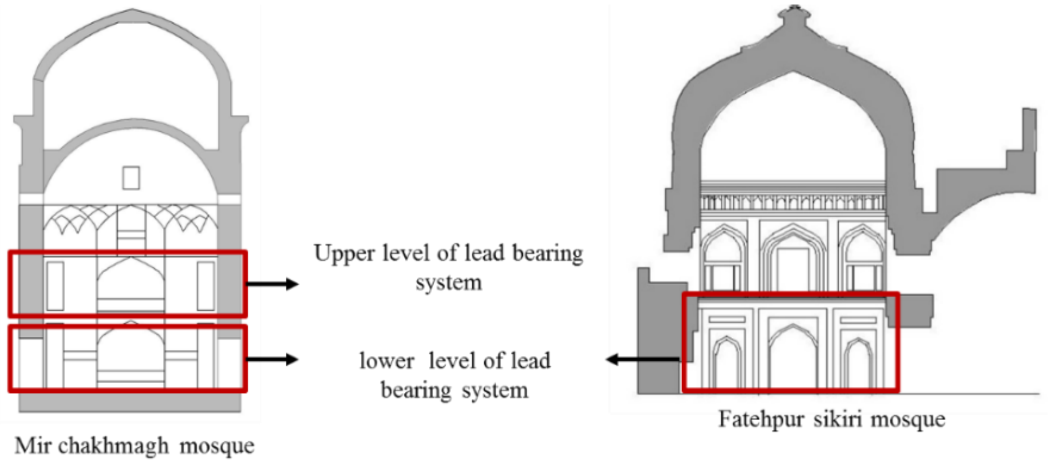


Figure 7.30: Load bearing system of domed (Author-2013)

7.3.2.8. Transitional System

Transitional system of Fatehpur sikri also like Mir chakhmaq mosque, which includes four arch and four *squinch.* But the changes can be seen in two points: firstly, separation of each arch and *squinch* with using vertical bands in early Mughal sample, in contrast of Timurid one that each arch link to the next with using" arch-net". Secondly , the lack of specific boundary in the up and down level of transition tier system in Mir chakhmagh mosque , even though two horizontal bands were applied in Fatehpur sikiri mosque(simple band in the lower level and the rows of little arches in the upper level) (see Figure7.31).

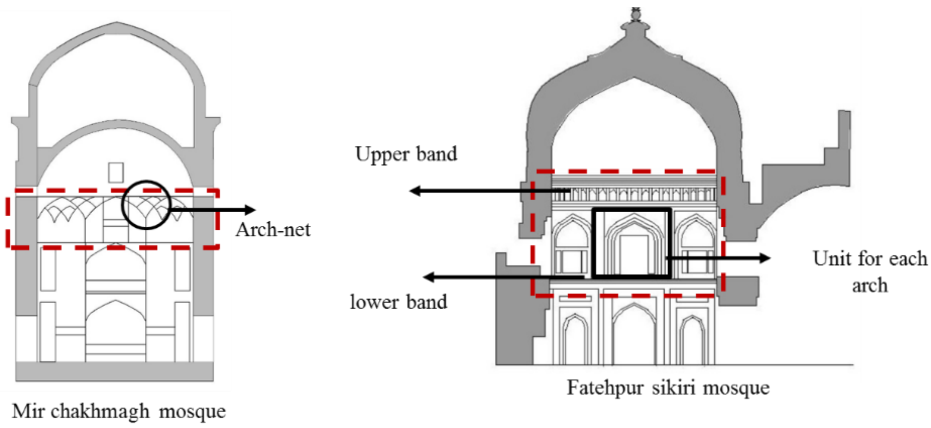


Figure 7.31: Transitional system of domed chamber (Author-2013)

7.3.2.9. Geometrical System of Domed Chamber

Based on Table 6.20 and Table D-4 (in the Appendix D), and comparison with Table (geometrical systems in Timurid domed chambers), more similarity with Timurid (particularly Gohar shad mosque and Mir chakhmaq mosque) can be seen in the plan (geometrical system four) (see Figure 7.32).

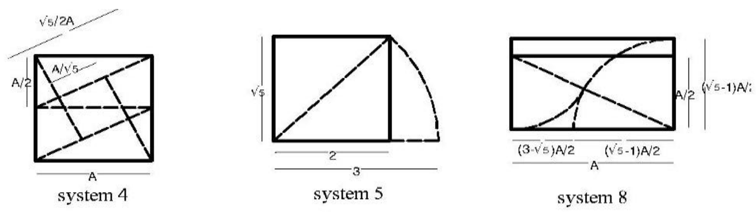


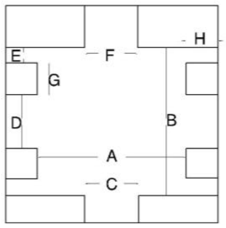
Figure 7.32: Used geometrical systems in domed chamber (Golombek et al., 1988)

7.3.2.10. Horizontal Proportion of Domed Chamber

With regard to Table D-4 (in the Appendix D) and Table 7.23, Table 7.24, and then the results compared with Timurid horizontal proportions (refer to Table 7.12). These points can be regarded; the proportions of horizontal dimensions of this domed chamber is more similar to Mir chakhmaq mosque with a little change; decrease the length of all open arches (entrance, *mihrab*, and vault tunnel to naves) and increase the length of wall between open arches.

Table 7.23: Horizontal proportions of domed chamber based on geometrical systems (Author-2013)

name of mosque	A	B	C	D	E	F	G	H
Fatehpur sikri mosque	a	a	a/4	a/4	a/8	a/4	$\sqrt{2}a/4$	a/2$\sqrt{5}$



Key of Table 7.23

Table 7.24: Horizontal proportions of domed chamber (Author-2013)

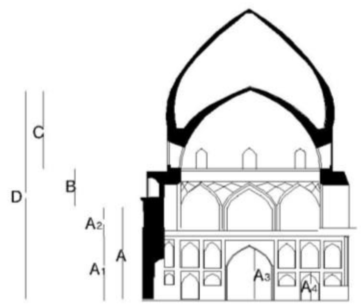
name of mosque	length	width	entrance	main vaulted tunnel	secondary vaulted tunnel	*Mihrab*	length of wall between corridors	thickness
Fatehpur sikri mosque	A	A	0.25A	0.25A	0.12A	0.25A	0.35A	0.25A

7.3.2.11. Vertical Proportion of Domed Chamber

Table 7.25 &Table 7.26 show the vertical proportions of Ftehpur sikiri mosque‘s domed chamber according to Table D-4 (in the Appendix D). The results, that were compared with Table including. The proportions between vertical dimensions in domed chamber of Ftehpur sikiri mosque is more equivalent to the late Timurid case study (Torbat jam mosque) specially in overall height of domed chamber. Height of internal dome (both of them have one shell dome), but some alteration can be seen: growth the height of transitional system and small decrease the height of load bearing system.

Table 7.25: Vertical proportions of domed chamber based on geometrical systems (Author-2013)

name of mosque	A	A_1	A_2	A_3	A_4	B	C	D
Fatehpur sikri mosque	a/2	a/2	-	$\sqrt{2}/4\ a$	$(\sqrt{5}a-1)4$	$(4+\sqrt{2})a/8$	$(\sqrt{2}/2-\sqrt{2}/4)a$	$(a/2+\sqrt{2}/2)a$



Key of Table 7.25

Table 7.26: Vertical proportions of domed chamber (Author-2013)

name of mosque	load bearing					transition tier	internal dome	domed chamber
	load bearing	lower section	upper section	main corridor	secondary corridor			
Fatehpur sikri mosque	0.5A	0.5A	-	0.35A	0.3A	0.65A	0.35A	1.2A

7.3.3. Double dome

The domes of Fatehpur sikiri mosque has one shell, so that it didn't follow Timurid architecture, which uses double dome.

7.3.4. Squinch

Architects in the early Mughal case study used several types of *squinch* that all types are similar to *squinches* in the Timurid case studies. These include groined vault with revetment of arch-net, a beam with revetment of arch-net (as simplest type of *squinch*), and groined vault. Even though in the smaller prayer halls behind domed chamber was applied the local Indian type of *squinch* in the corner of transition tier section (refer to Figure 6.92).

7.3.5. Pointed arch

With regard to Table 6.22and Table 7.18, the similarity between Fatehpur sikiri mosque and Timurid case studies can be seen in using arch type 3-1 that called "*Panj-O Haft*

Tond” in Persian architecture .In addition , the other arch type, type 3-2(*Panj-O Haft Kond)*, also was used in this Mughal mosque. The former was used in most of the spaces both inside and outside, and the later was used for covering main vault of east and south entrance (very big spaces). These two arch type is very similar to each other and they are from one category (*Panj-O Haft)* .type 3-2 is suitable for covering bigger spaces, so that the slope of arch is less in order to cover big space .

7.3.6. Main Findings of Timuird Elements in Early Mughal Mosque

Table 7.27presents the main finding of Timurid architectural elements in early Mughal period case study (shah mosque) based on five Persian architectural elements (Ivan, domed chamber, double dome, *squinch*, and pointed arch).

Table 7.27: Summery of Timurid elements in early Mughal period (Author-2013)

Persian element	feature	**Early Mughal** case study **(Fatehpur sikri mosque)**	**Timurid** case studies	Level of similarity		
				none	moderate	high
Ivan	number	three number of Ivans	four number of Ivans(CS1,CS2)	✓		
	relation	West *ivan*: relation with all behind spaces from four side	South Ivan and others were related to all space in the around them(CS2)		✓	
		east *ivans* : relation with only corridor and courtyard	Relation with domed chamber and courtyard from two sides (CS1-south *ivan*)			✓
	placement	Center of each side and in the line with behind space(east *ivan*)	Center of each side and in a line to behind facade(all CSs)			✓
		Center of each side and in front of behind spaces(west & south *ivans*)		✓		
	form	The typical horizon form of Ivan is rectangle	The typical horizon form of Ivan is rectangle(all CSs)			✓
	Structure of ceiling	Only west *ivan* was covered by semi dome and others by vault tunnels	*Ivans* were covered by vaulted tunnels (all CSs)		✓	
	material	Main material is red sand stone with elaboration of yellow stone and mosaic	The dominant material was mosaic fiancé chiefly for external of *Ivans* (CS1, CS2), plaster (CS2, CS3) for internal.	✓		
	Qibla ivan ‘s façade	*qibla Ivan* is more similar to CS1 only in using mini minaret, *chhatris*, parapet,	a form of *qibla Ivans* comprised” a band throughout *Ivan*, a spandrel, a plinth ,open arch, inscription frieze and two big minarets “which extended to ground(CS1)		✓	
	Other *Ivans* ‘s facade	Other ivans is similar to Timurid specially east one, south ivan comprise three big open arch	Typical form of *Ivans* that including: a band throughout *Ivan*, a spandrel, a plinth, open arch. (all CSs)		✓	
	Persian geometrical systems (*qibla* Ivan)	In the façade, the similar pattern is 2,5	In the façade, the most useful systems were 1, 2, 5, and 8. (all CSs)		✓	
		systems 3, 4 are most useful in plan	systems 3, 4 are most useful in plan(all CSs)			✓
		Ratio of length to width and height is similar to CS2				✓
		the height of dome is the same CS1				✓

Persian element	feature	**Early Mughal** case study **(Fatehpur sikri mosque)**	**Timurid** case studies	Level of similarity none	moderate	high
Ivan	Persian geometrical Patterns (other façade)	pattern 1,2(only south ivan) were used façade of others	Pattern 1,2,5, 8 are most usage pattern in the facade of other *Ivans*		✓	
		Pattern 4 can be seen in the plan	Pattern 1, 3, 4 can be seen in the plan(all CSs)		✓	
		Other ivan have different proportions due to diverse form	Other *Ivans* have more match in ratio of length to width and height(all CSs)	✓		
Domed chamber	form	The form of domed chamber was square	the form of domed chamber was square (CS1, CS2)			✓
	relation	Relation of domed chamber with naves in three vaulted tunnels in both side				✓
		Relation with *mihrab* and *qibla ivan* with in three opening	Relation with *mihrab* and *qibla ivan* with in one opening	✓		
		Similarity with CS2 in using different type and size of vaulted tunnels to naves				✓
		Persian Powerful combinational patterns (*Ivan*, domed chamber, *Mihrab*) similar to all CSs				✓
	Load bearing system	Positive shape in domed chamber only can be seen in Mihrab and other three sides have negative shapes (opening to *Ivan* and naves) similar to all CSs				✓
		More analogous with CS2 , in using typical pattern (open arch-blind arch 0open arch , open arch) with some change :decrease two horizontal section to one			✓	
		Main difference is in the number of mihrab (three)		✓		
	transitional system	Fatehpur sikri mosque followed CS2 with some alteration omission arch-net between main arches, highlight vertical division between main arches			✓	
	material	Red sand stone	plaster as dominate material	✓		
	windows	Four windows like CS2 and specially withCS3(in size and position),				✓
	Geometry and proportion	Using Persian geometrical systems 5,8 in facade	Using Persian geometrical systems1 in facade CS1, CS2), and 4 (CS1, CS3).	✓		
		Using Persian geometrical systems 4,5 in plan	Using Persian geometrical systems in plan 3, 4 (all CSs), and 1 (CS2, CS3).		✓	
		The ration of length to width (combination three spaces is similar particularly CS 1,2				✓
		The ration of length to width for *mihrab* is dissimilar with all CSs		✓		
		The ration of length to width for Ivan was similar CS3 with decrease of size			✓	

Persian element	feature	**Early Mughal** case study **(Fatehpur sikri mosque)**	**Timurid** case studies	Level of similarity		
				none	moderate	high
Domed chamber	Geometry and proportion	The ration of length to width for domed chamber can't match with all CSs		✓		
		The horizontal proportions of domed chamber is more similar CS2 with some alteration			✓	
		All opening like *mihrab* , entrance , vaulted tunnels to naves have different length dissimilar with all CSs		✓		
		Central symmetry for all sides	✓			
		domed chamber's thickness was 0.25 A		✓		
		Height of internal dome(0.35A) domed chamber's height (1.2A) and similar to CS3				✓
		growth the height of transitional system and small decrease the height load bearing system dissimilar with all CSs		✓		
Pointed arch	Type	The most appropriate arch was type 3-1 both small ,low and big ,high spaces	type 3-1, 5are suitable for wide and high spaces(all CSs)			✓
	Type		Type 4-1,6-1,6-2 are appropriate small and low space(all CSs)	✓		
squinch	Type	Groined vault with revetment of arch-net, Groined vault , A beam with revetment of arch-net	Groined vault with revetment of arch- net (CS2), A beam across the corner with revetment of arch-net (CS1)			✓
	material	red sand stone	plaster	✓		

$CS_{1:}$ Gohar shad mosque (first Timurid case studies)
$CS_{2:}$ Mir chakhmaq mosque (second Timurid case studies)
$CS_{3:}$ Torbat Jam mosque (third Timurid case studies)

7.4. Phase Two-Level Two: The Comparison between Timurid and Safavid Case Studies Based on Third Proposition

In this level of results, Shah Mosque as Safavid case study was compared with Timuird case studies. This section is level two of phase two (belongs to third proposition of Timurid influence in Mughal architecture -indirect influence of Timurid architecture in high Mughal mosque via Safavid era).

7.4.1. Ivan

Shah mosque like Timurid case studies (Goharshad mosque, Mir chakhmaq mosque) followed the most popular Persian mosque type- four *Ivans* mosques.

7.4.1.1. Relation of Ivans

Shah mosque was completely similar to Mir Chakhmaq mosque in using relational patterns with functional elements. All *ivans* were associated to adjacent space (naves, domed chamber, corridors) by vaulted tunnels (see Figure 7.33).

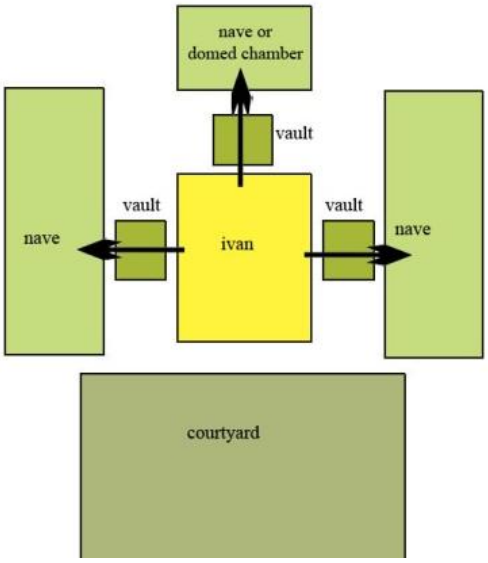


Figure 7.33: Pattern of relation of *ivans* with other behind spaces (Author-2013)

7.4.1.2. Form

The type of of *ivans*'s form in shah mosque, similar to all Timurid case studies, is rectangle, and the size of each diverse based on the position of *ivan.*

7.4.1.3. Structure of Ceiling

All *Ivans* of Shah Mosque surrounded by tiers of *muqarnas* forming semi-domes.

7.4.1.4. Material

As it was mentioned in literature review (4.4.9), the prevailing material in both entrant and external of Safavid buildings was polychrome or seven colors that named "Haft Rang" tile in Persian language .Four *ivans* of Shah Mosque fully embellished by polychrome (seven color tile) with colors dark blue, white, green, above high continuous marble dado, (see Figure 6.67).

7.4.1.5. Elements of Ivan Screen

South *Ivan* of Shah Mosque is more similar to Goharshad mosque in using inspiration frieze, minarets with slight alteration such as the minarets of Shah Mosque extended from top of behind façade. Moreover, using *muqarnas* system as revetment of covering, continuance of domed chamber's articulation in internal façade of *Ivan* (load bearing system and transition tier) and also omission of inscription frieze are particular feature of Shah mosque that didn't use in Timurid samples (see Figure7.34). Other *Ivans* were composed of mixture the typical Timurid form of Ivan and special characteristic of this mosque.

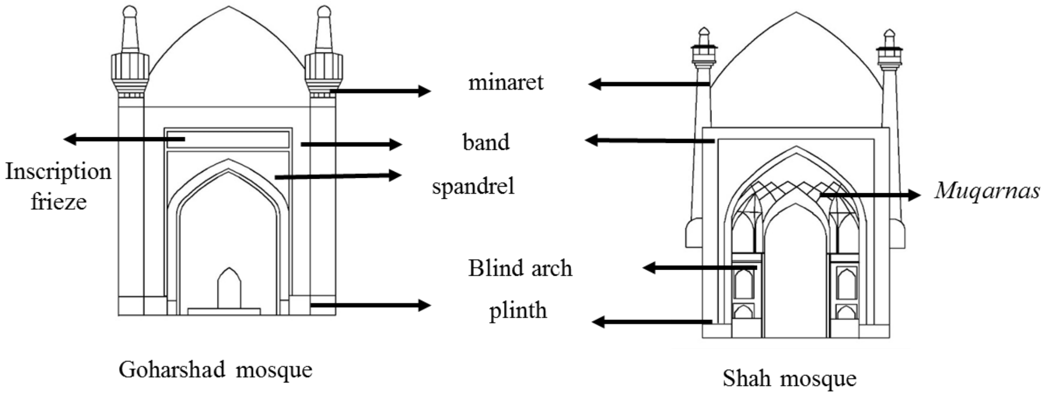


Figure 7.34: Elements of south i*van*'s façade (Author-2013)

7.4.1.6. Geometrical System and Proportions of Ivans

Table D-5 (in the Appendix D) and Table 6.14 represents the geometrical analysis of Shah Mosque based on Persian geometrical systems that was shown in Figure 7.35. In comparison of shah mosque and Timuird case studies (Table), Shah Mosque continued the manner of Timurid mosques in both plan and façade. For example: south *Ivan* of shah mosque is similar to Timurid mosque, particularly with Mir chakhmag mosque that geometrical systems comprise: one, two, five, and eight for façade .and also one, four, and five for plan. For other *Ivans*, the geometrical systems that were applied in Shah Mosque in both plan and façade is similar to Timurid case studies.

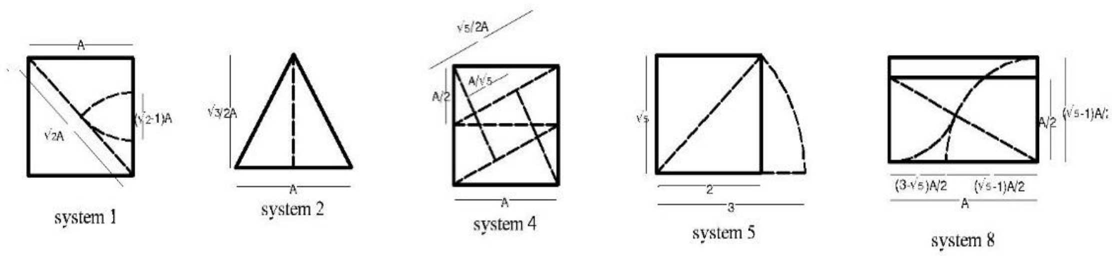


Figure 7.35: Used geometrical systems in shah mosque's ivans(Golombek et al., 1988)

Table 7.28 shows the proportion of *ivans* based on Persian geometrical systems With regarding Table D-5 (in the Appendix D), then the revised results show in Table 7.29. In comparison this table and proportions of Timuird *ivans* (Table 7.3, Table 7.5, Table 7.7), south *ivan* of Shah Mosque is so similar to Gohar Shad mosque for the reason that both of them were as Jami mosques. Exceptions the height of dome in Safavid mosque is higher than Gohar Shad mosque. Beside that, Timurid proportions of other *ivans* diminished in both vertical and horizontal dimensions of Shah mosque.

Table 7.28: Proportions of *ivans* based on Persian geometrical systems (Author-2013)

name of ivan	length	width	height	height of minarets	height of dome
South ivan	$\sqrt{3}a$	$\sqrt{3}/2a$	$\frac{(\sqrt{2}+2)a}{2}$	$(\sqrt{2}+1)a$	$\frac{\sqrt{5}(\sqrt{2}+2)a}{2}$
North ivan	$\sqrt{3}a$	a	$\sqrt{2}a$	-	-
East and west ivan	$\sqrt{3}a$	a	$\sqrt{2}a$	-	-

Table 7.29: Proportions of Ivan (Author-2013)

name of ivan	length	width	height	height of minarets	height of dome
South ivan	A	0.5A	A	1.4A	2.2A
North ivan	A	0.6A	0.8A		
East and west ivan	A	0.6A	0.8A		

7.4.2. Domed Chamber

7.4.2.1. Form

Square pattern that was used in two Timurid case studies (Goharshad and Mir chakhmaq mosque), repeated in the Shah mosque of Safavid period.

7.4.2.2. Relations of Domed Chamber

Domed chamber of Shah Mosque is more similar to second Timurid case study (Mir Chakhmaq mosque). In comparison of Timurid sample, the size of entrance and central vaulted tunnel are wider so that the central space appeared brighter and more fluid (see Figure 7.36& Figure 7.7).

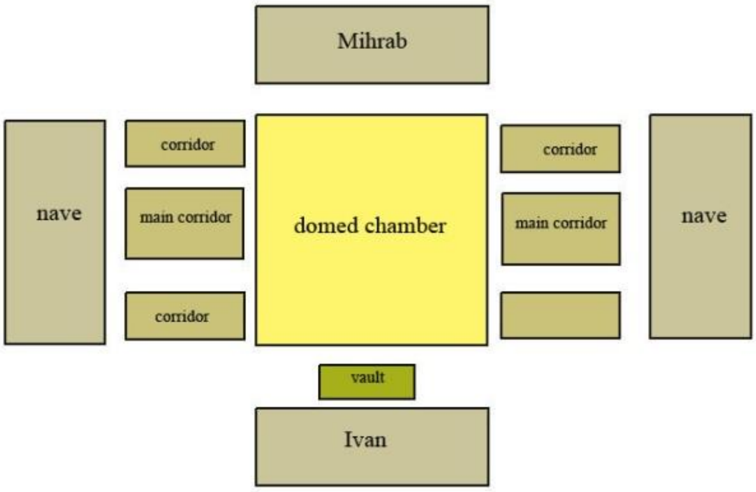


Figure 7.36: Organization and relation with other spaces of domed chamber (Author-2013)

7.4.2.3. Combination of Domed chamber, Ivan & Mihrab

Shah mosque was designed based on the popular combinational patterns between domed chambers, *Ivan*, *mihrab* that is similar to all Timurid case studies.

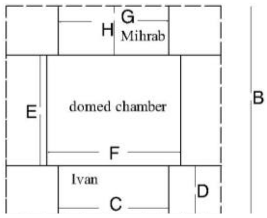
7.4.2.4. Proportions between domed chamber, Ivan and mihrab

Table XII (in Appendix) shows geometrical analysis of Shah Mosque based on Persian geometrical system. Table 7.30 represents the proportion of this mosque based on results of Table XI. Then the revised results that display in Table 7.31 , were compared with proportions of Timurid domed chambers (refer to Table 7.9). These points can be regarded as below:

- In comparison of Timurid samples, the ratio of length -to -width decreased in Shah Mosque.
- The ratio of length- to -width for south *ivan* , *mihrab* and domed chamber are similar to Timurid case studies, especially with Torbat jam mosque (in south Ivan), but the proportions of domed chamber and *mihrab* declined .so that domed chamber of Shah mosque appeared in the smaller dimension than Timurid ones .

Table 7.30: Horizontal proportions of combination domed chamber, *Ivan &mihrab* based on Persian geometrical systems (Author-2013)

name of mosque	A	B	C	D	E	F	G	H
Shah Mosque	$\sqrt{3}$a	$(\sqrt{6}-\frac{\sqrt{3}}{2\sqrt{5}})$a	a	$\sqrt{3}\left(\frac{\sqrt{2}}{4}\right)a$	$\frac{\sqrt{3}a}{\sqrt{2}}$	$\frac{\sqrt{3}a}{\sqrt{2}}$	$(\sqrt{2}-1)$a	$\sqrt{3}/2\left(1-\left(\frac{\sqrt{2}}{2}\right)\right)$a



Key of Table 7.30

Table 7.31: Horizontal proportions of combination domed chamber, *Ivan &mihrab* (Author-2013)

name of mosque	**combination Ivan+ domed chamber+ *Mihrab***			**Ivan**		**domed chamber**		***Mihrab***	
	length	width	length /width	length	width	length	width	length	width
Shah Mosque	1.7A	2A	1.2	A	0.6A	1.2A	1.2A	0.4A	0.2A

7.4.2.5. Windows

Windows of the Shah mosque are combination of the windows in Mir Chakhmaq and Torbat Jam mosques, but the number of aperture in internal dome level in more(six apertures) and the size of lower windows are bigger than Timuird mosque(see Figure 7.37 & Figure 7.10).

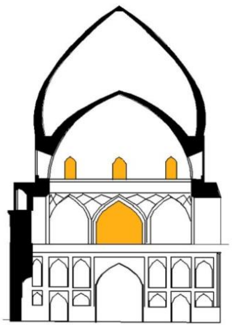


Figure 7.37: Position of windows in domed chamber (Author-2013)

7.4.2.6. Material

Seven color was applied with variable colors and floral motifs in domed chamber of Shah Mosque (see 6.67).

7.4.2.7. Load Bearing System

In the Safavid case study, like the Timurid case studies, positive shape only can be seen in *Mihrab* and other three sides have negative shapes (opening to *Ivan* and naves). The decline of load bearing‘s height in three Timurid samples, was continued in Shah Mosque (more details descried in geometry and proportion of domed chamber). Shah mosque is more analogous to Mir Chakhmaq mosque, with more vertical articulation (blind (open) arch, main blind (open) arch- blind (open) arch) and central vaulted tunnel posit in one level unlike Mir Chakhmaq. (See Figure 7.38).

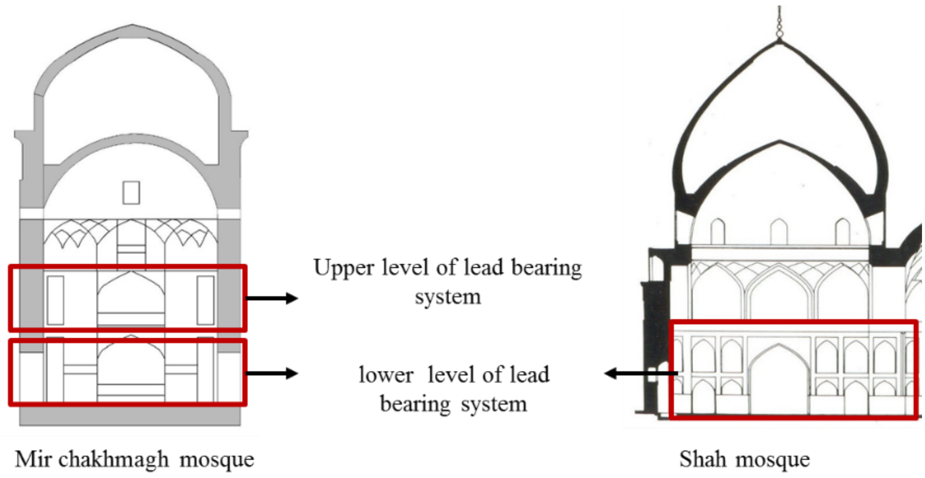


Figure 7.38: Load bearing systems (Author-2013)

7.4.2.8. Transitional System

The Safavid case study (Shah Mosque) also was continued using *squinch* with faintly alteration: increase the height of this system, using horizontal bands in up and down of it in order to separation from lead bearing system (see Figure 7.39).

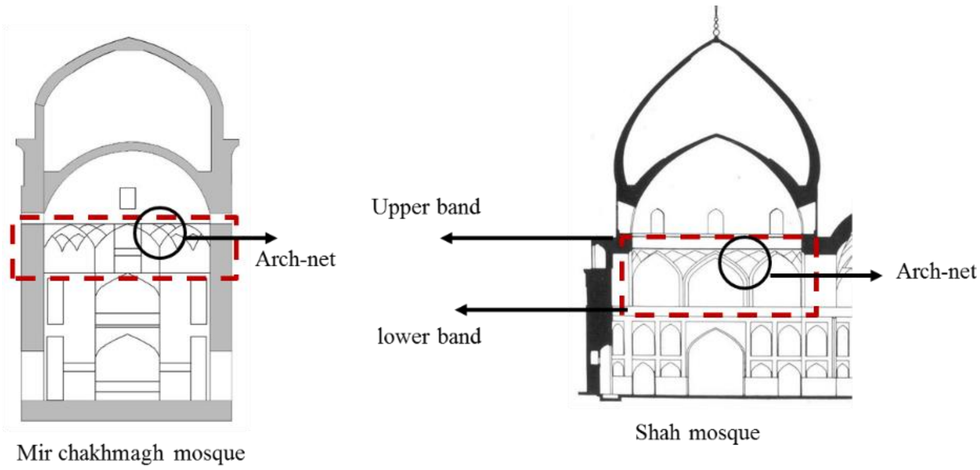


Figure 7.39: Transitional systems (Author-2013)

7.4.2.9. Geometrical System of Domed Chamber

With regard to Table D-5 (in the Appendix D) and Tble 6.15 show using Persian geometrical systems in both façade and plan of internal domed chamber of Shah Mosque .In comparison between this table and Table 7.10 ,these points can be seen.

- In the plan of Shah Mosque like Timurid samples, the most systems that was applied were in order three, four, and one.
- The similar geometrical system in façade between Safavid and Timurid case studies were one, four (Figure 7.40).

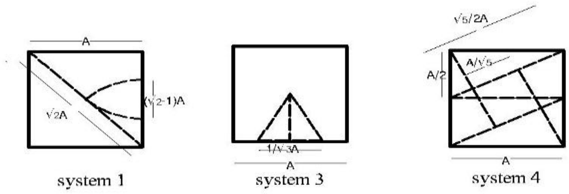


Figure 7.40: Useful Persian geometrical systems in domed chamber (Golombek et al., 1988)

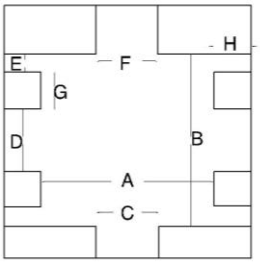
7.4.2.10. Horizontal Proportion of Domed Chamber

Figure 7.32 shows horizontal proportion of domed chamber based on Persian geometrical systems (refer to Table D-5 in the Appendix D). Then results were summarized in Table 7.33. With comparison this table andTable 7.12 (horizontal proportion of Timruid domed chamber), these points can be achieved:

- Shah mosque generally is more similar to Mir Chakhmaq mosque in length proportion but with decrease in all size.
- In both of Mir Chakhmaq and Shah mosques , all main opening including *mihrab* , entrance , main vaulted tunnel have same length ,but length of *ivan* in Shah mosque is equivalent *mihrab* and all vaulted tunnels are similar .

Table 7.32: Horizontal proportions of domed chamber based on Persian geometrical systems (Author-2013)

name of mosque	A	B	C	D	E	F	G	H
Shah Mosque	a	a	$\frac{(\sqrt{5}-1)a}{2\sqrt{5}}$	$\frac{(\sqrt{5}-1)a}{2\sqrt{5}}$	$\frac{(9-3\sqrt{5})a}{8\sqrt{5}}$	$\frac{(\sqrt{5}-1)a}{2\sqrt{5}}$	$\frac{(11-3\sqrt{5})a}{8\sqrt{5}}$	$\frac{a}{2\sqrt{5}}$



Key of Table 7.32

Table 7.33: Horizontal proportions of domed chamber (Author-2013)

name of mosque	length	width	entrance	main vaulted tunnel	secondary vaulted tunnel	*mihrab*	length of wall between corridors	thickness
Shah Mosque	A	A	0.3A	0.3A	0.1A	0.3A	0.2A	0.2A

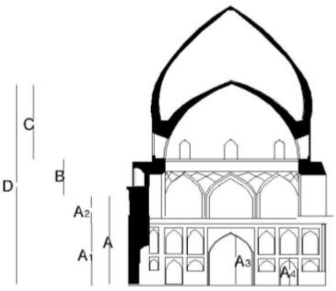
7.4.2.11. Vertical Proportion of Domed Chamber

As similar the process in horizontal proportions, the results that were achieved (firstly from Table D-5 and then Table 7.34) represents in Table 7.35. With comparison, these results and Table 7.14(Timurid vertical proportions).these points can be regarded:

- Ratio of lead bearing‘s height to internal height was parallel to Torbat jam mosque
- In other height such as internal dome and domed chamber is more similar to Mir chakhmaq mosque.
- The height of main and secondary vaulted tunnels are not the same in Shah Mosque, even though the equal height in Timurid samples.
- Generally, the main difference between Timurid and Safavid case studies is the division between load bearing and transition height, Shah Mosque has lower lead bearing and higher transition tier, so that Timurid one appeared higher than Shah Mosque.

Table 7.34: Vertical proportions of domed chamber based on Persian geometrical systems (Author-2013)

name of mosque	A	A_1	A_2	A_3	A_4	B	C	D
Shah Mosque	$a/2$	a/2	$\frac{(\sqrt{2}-2)a}{2}$	$\frac{\sqrt{2}(\sqrt{5}-1)a}{2\sqrt{5}}$	$\frac{\sqrt{2}(\sqrt{5}-1)a}{4\sqrt{5}}$	$a/2$	a/2	3a/2



Key of Table 7.34

Table 7.35: Vertical proportions of domed chamber (Author-2013)

name of mosque	load bearing					transition tier	internal dome	domed chamber
	load bearing	lower section	upper section	main corridor	secondary corridor			
Shah Mosque	0. 5A	0.5A	0.2A	0.4A	0.2A	0. 5A	0.5A	1.5A

7.4.3. Double Dome

7.4.3.1. External Shell

Shah mosque continued the manner of early Timurid mosque(Goharshad Mosque).The type of external shell was bulbous with slightly change in comparison to Goharshad Mosque(the lower arch was less curve) (Figure 7.41).

7.4.3.2. Internal Shell

Safavid mosque (Shah Mosque) has deigned according to pointed formation that caused to increase the height of internal domed chamber (Figure 7.41).

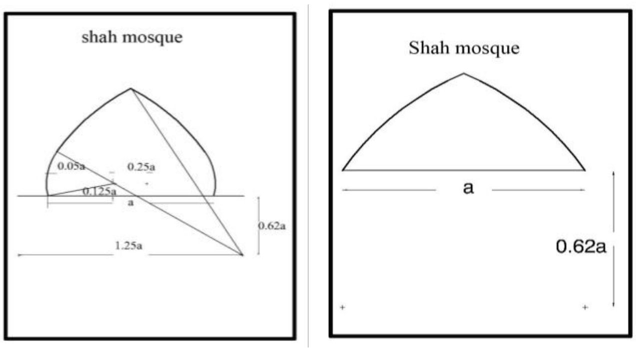


Figure 7.41: Type of external and internal shell of double dome (Author2013)

7.4.3.3. Proportion of External Shell

With comparison between Table 7.36 and Table 7.16 ,it can be concluded that shah mosque followed Goharshad Mosque in using bulbous dome, Even though both Goharshad and Shah Mosques were designed for congregational purpose .the first mosque has bigger proportion in whole sections of external shell.

Table 7.36: Proportions of external shell of double dome (Author-2013)

Name of mosque	Bulbous dome					
	L_1	H_1	L_2	H_2	L_3	H
Shah Mosque	0.25a	0.125a	1.25a	0.62a	0.05a	0.75a

7.4.3.4. Material

Safavid sample was used the seven color tile in both internal and external shell.

7.4.3.5. Thickness

Similar the Timurid case studies, the thickness of both internal and external shells gradually reduced from the base to the top of dome.

7.4.4. Squinch

Shah mosque as Safavid case study followed Mir Chakhmaq mosque in using groined vault but with more simple face (without *squinch*-net) (refer to Table 7.17).

7.4.5. Pointed Arch

Based on section 2.3.5 of chapter two, one of the main characteristic of Safavid architecture was simplicity in geometry and using identical size in the plan and façade of buildings and also more attention to human proportions .So that Safavid architects preferred to use the special arch that can cover both small ,low and big ,high spaces . The most appropriate arch was type 3-1 (*Panj-O Haft*) for inside and outside of Shah Mosque. This arch was used for both wide, high and low spaces (refer to Table 7.18).

7.4.6. Main Findings of Timurid Elements in the Safavid Mosque (Shah Mosque)

Table 7.33 presents the main finding of Timurid architectural elements in Safavid case study (shah mosque) based on five Persian mosque elements (*Ivan*, domed chamber, double dome, *squinch*, and pointed arch).

Table 7.33: Level of similarity between safavid and Timurid case studies (Author-2013)

Persian element	feature	**Safavid** case study **(Shah mosque)**	**Timurid** case studies	Level of similarity		
				none	moderate	high
Ivan	number	four number of Ivans	four number of Ivans(CS1,CS2)			✓
	relation	South Ivan and others were related to all space in the around them	South Ivan and others were related to all space in the around them(CS2)			✓
	placement	Center of each side and in a line to behind facade	Center of each side and in a line to behind facade(all CSs)			✓
	form	The typical horizon form of Ivan is rectangle	The typical horizon form of Ivan is rectangle(all CSs)			✓
	Structure of ceiling	all *Ivans* of Shah Mosque surrounded by tiers of *muqarnas* forming semi-domes	*Ivans* were covered by vaulted tunnels (all CSs)	✓		
	material	Four *Ivans* of Shah Mosque fully embellished by polychrome (seven color tile)	The dominant material was mosaic fiancé chiefly for external of *Ivans* (CS1, CS2), plaster (CS2, CS3) for internal.	✓		
	South Ivan 's facade	South *Ivan* is more similar to CS1 only slight alteration such as minarets extended from top of behind façade. Moreover, using *muqarnas* system	a form of south *Ivans* comprised" a band throughout *Ivan*, a spandrel, a plinth ,open arch, inscription frieze and two big minarets "which extended to ground(CS1)		✓	
	Other *Ivans* 's facade	Other *Ivans* were composed of mixture the typical Timurid form of Ivan and special characteristic of this mosque.	Typical form of *Ivans* that including: a band throughout *Ivan*, a spandrel, a plinth, open arch. (all CSs)		✓	
		open vaulted was connection between south *Ivan* and domed chamber	open vaulted was connection between south *Ivan* and domed chamber (CS2)			✓

Persian elements	feature	**Safavid** case study **(Shah mosque)**	**Timurid** case studies	Level of similarity: none	moderate	high
Ivan	Persian geometrical Systems and proportions (south Ivan)	In the façade, the most useful systems were 1, 2, 5, and 8.	In the façade, the most useful systems were 1, 2, 5, and 8. (all CSs)			✓
		systems 3, 4 are most useful in plan	systems 3, 4 are most useful in plan(all CSs)			✓
		Ratio of length to width and height is similar to CS1				✓
		Ratio length to height is the same	Ratio length to height is the same (all CSs)			✓
		Among these miner demotions, vertical elements have more similar proportion rather than the horizontal elements(all CSs)				✓
	Persian geometrical Systems and proportions (other façade)	systems 1,5,8 were used in the facade of other *Ivans*	systems 1,2,5, 8 are most usage pattern in the facade of other *Ivans*		✓	
		systems 1, 3, 4 can be seen in the plan	systems 1, 3, 4 can be seen in the plan(all CSs)			✓
		Other *Ivans* have more match in ratio of length to width and height	Other *Ivans* have more match in ratio of length to width and height(all CSs)			✓
		Shah mosque has less deep and high *Ivans* than Timurid			✓	
Domed chamber	form	The form of domed chamber was square	the form of domed chamber was square (CS1, CS2)			✓
	relation	relation of domed chamber to nave with three vaulted tunnels in both sides	relation of domed chamber to nave with three vaulted tunnels in both sides(all CSs)			✓
		Difference in size and type of central vaulted tunnel to naves	The central vaulted tunnels to naves increased the size and differenced the type of vault.(SC2)			✓
		High relation between domed chamber and south *Ivan* and *Mihrab*	High relation between domed chamber and south *Ivan* and *Mihrab* (CS2, CS3).	✓		
		Persian Powerful combinational patterns (*Ivan*, domed chamber, *Mihrab*)	Persian Powerful combinational patterns (*Ivan*, domed chamber, *Mihrab*) (all CSs).			✓
	load bearing system	Positive shape in domed chamber only can be seen in Mihrab and other three sides have negative shapes (opening to *Ivan* and naves)	Positive shape in domed chamber only can be seen in Mihrab and other three sides have negative shapes (opening to *Ivan* and naves) (all CSs).			✓
	transitional system	Shah Mosque also was continued using squinch with faintly alteration	Usage of popular Persian transitional system – squinch with revetment of arch -net (CS1, CS2),		✓	
		mosque this transition system was bold and specific with ending line	mosque this transition system was bold and specific with ending line(CS2)			✓

Persian elements	feature	**Safavid** case study **(Shah mosque)**	**Timurid** case studies	Level of similarity: none	moderate	high
Double dome	Material	the seven color tile(polychrome) in both internal and external shell	washed plaster internally and mosaic fiancé externally(CS1,CS2)	✓		
	thickness	Reduction gradually from the base to tope externally , internally	Reduction gradually from the base to tope externally , internally(CS1,CS2)			✓
squinch	Type	Groined vault of squinch without arch-net (squinch net).	Typical type of Timurid squinch - groined vaults-with additional ornamentation (arc-net) (CS2).		✓	
	material	Seven color mosaic	plaster	✓		
Pointed arch	Type	The most appropriate arch was type 3-1 both small ,low and big ,high spaces	type 3-1, 5are suitable for wide and high spaces(all CSs)			✓
	Type		Type 4-1,6-1,62 are appropriate small and low space(all CSs)	✓		

7.5. Phase Two - Level Three: Comparison Safavid and high Mughal Case Studies Based on Third Proposition

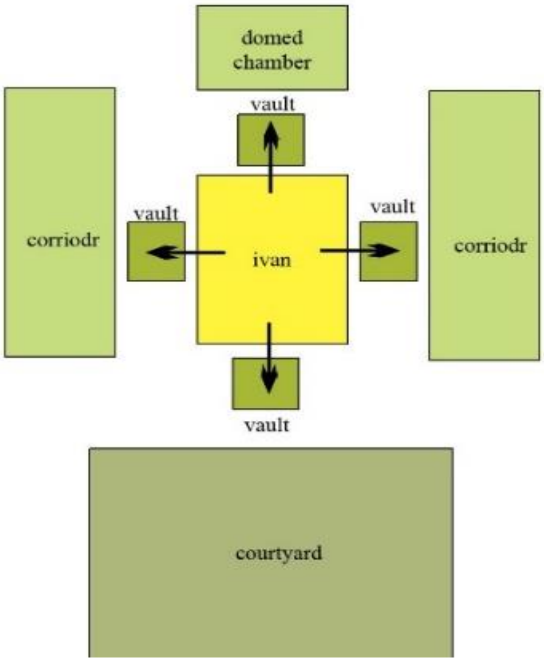
In this level of results, Taj mahal and Delhi Jami mosque as high Mughal case studies were compared with Safavid case study. This section is level three of phase two (for third proposition of Timurid influence in Mughal architecture -indirect influence of Timurid architecture in high Mughal mosque via Safavid era).

7.5.1. Ivan

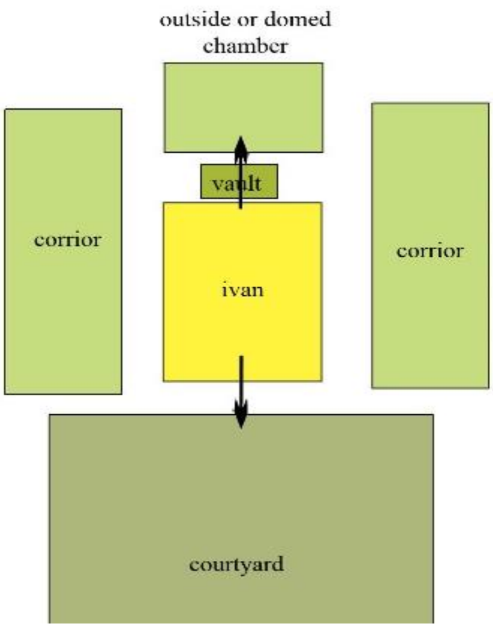
Taj mahal mosque is part of big Taj mahal complex that is placed behind the tomb of Taj mahal. This mosque was designed based on domed *Ivan* (kiosk) mosque that described in section 4.3.1 of literature review .So that it has one *Ivan* in the center. The other high Mughal case study, Delhi Jami mosque- as the biggest traditional mosque in the contemporary India, was designed based on four *Ivan* mosque (the popular Persian mosque type) similar with Shah Mosque.

7.5.1.1. Relation of Ivans

The west *Ivan* (*qibla Ivan*) of Taj mahal mosque is totally similar to Shah Mosque. It was linked and connected to all behind spaces (refer to Figure 7.42a), however the Delhi Jami mosque was only linked to domed chamber (refer to Figure 7.42, b). The other rational patterns that were used in the north and south *ivans* and east *ivan* of Delhi Jami mosque can’t be match with patterns of Shah mosque , and these *ivans* followed in early Mughal case study due to merge with gateway complex (see Figure 6.117).



a



b

Figure 7.42: Patterns of relation of *ivans* with behind spaces (Author-2013)

7.5.1.2. Form

Form of Taj Mahal & Delhi mosque‘s *ivans* are rectangular, however only west *ivan* is like Safavid *ivans* , the others combined with vestibule of gateways and have long length and small width .

7.5.1.3. Structure of Ceiling

Like Shah Mosque, the west *Ivan* of Taj Mahal &Delhi mosque was covered by semi dome, and the other *ivans* were roofed by vault tunnel.

7.5.1.4. Material

Unlike Safavid case study the material for west *Ivan* of Taj Mahal is mixed of white marble and red sand stone .moreover west *Ivan* of Delhi Jami mosque is white marble with revetment of red sand stone, but others totally were elaborated with red sand stone (see Figure 101 & Figure 117).

7.5.1.5. Elements of Ivan's Facades

West *ivan (qibla ivan*): the similarity and difference between high Mughal and Safavid case studies can be classified in these points(see Table 7.40 and Figure 7.43):

- Similarity with both Mughal mosques: using open arch, band, spandrel
- Similarity with Taj mahal Mosque: using plinth, *muqarnas*, type of open arch
- Similarity with Delhi Jami Mosque: using minaret, the size of band.
- Difference with both high Mughal ones: using parapet, floral patterns in the internal walls instead of blind arch.

East and south *ivan*s: other *ivans* of Delhi Jami mosque have different patterns in comparison west *ivan.* The north and south *ivans* comprise two horizontal level and the east one has three horizontal level. These *ivans* are totally different with *ivans* of Safavid case study (Tble 7.40 &Figure 6.119).

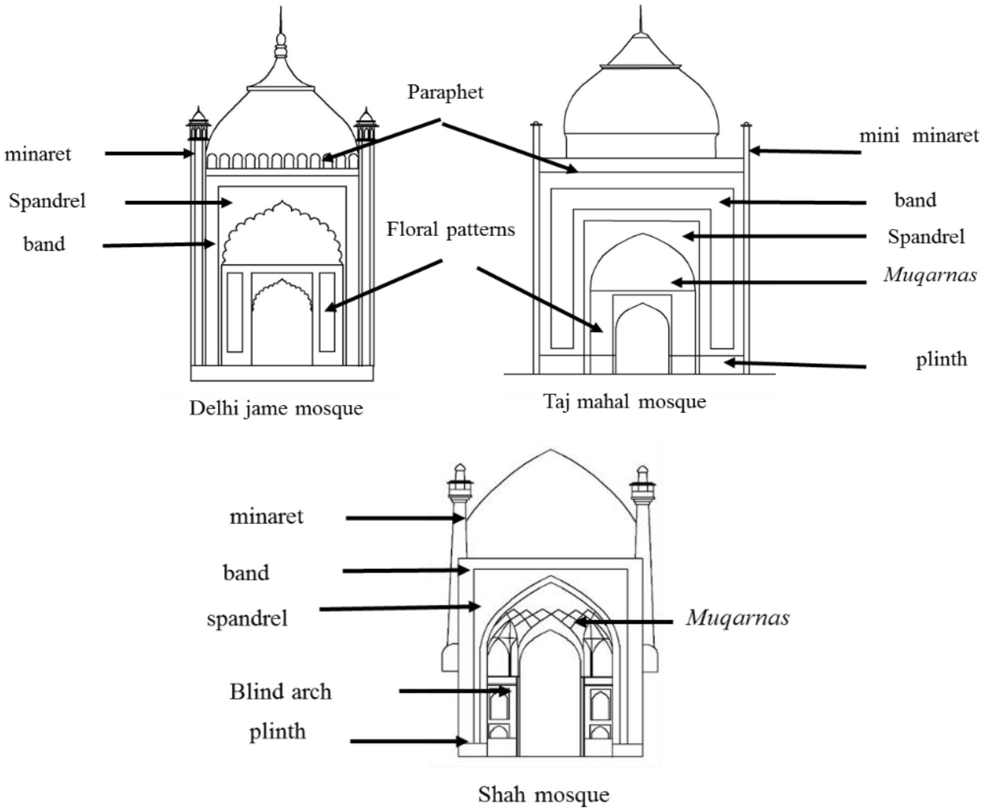


Figure 7.43: Elements of west ivans' façade (Author-2013)

7.5.1.6. Geometrical System and Proportions of Ivans

Gibla *Ivan*: Table D-6 & Table D-7 (in the Appendix D) and Table show geometrical analysis of high Mughal mosque based on Persian geometrical system. In comparison between high Mughal mosques and Shah Mosque (see Table 6.14), geometrical systems of gibla *Ivan*'s façade cannot be match, and only geometrical system four was used in the plan of all Safavid and high Mughal case studies.

Table 7.38 and then Table 7.39 shows the proportions of high Mughal west *ivans* ,even though low similarity between Safavid and high Mughal mosque in using geometrical systems, there can be seen high similarity in proportions of *qibla ivan* between Safavid and high Mughal mosques exception the height dome in later Mughal case study(see Table 7.29) .

Table 0.1: Proportions of west *ivans* based on Persian geometrical systems (Author-2013)

name of mosque	length	width	height	height of minarets	height of dome
Taj Mahal mosque	$(2/\sqrt{5}-1)a$	$\sqrt{2}/2$a	2a	-	3a
Delhi Jami Mosque	$\sqrt{3}$a	$2/\sqrt{5}a$	$(2+\sqrt{2})a/2$	$(1+(1/\sqrt{5})\sqrt{3}a$	$(2+\sqrt{2})\sqrt{3}a/2$

Table 0.2: Proportions of west *ivans* (Author-2013)

name of mosque	length	width	height	height of minarets	height of dome
Taj Mahal Mosque	A	0.4A	A	-	1.5A
Delhi jami Mosque	A	0.5A	A	1.4A	1.7A

Other *ivans*: for other *ivans* of Delhi Jami mosque, only the geometrical systems can be studied, because the form of *ivans* is completely altered with Safavid one. In the façade, system one in used in both case studies (Shah Mosque and Delhi Jami mosque), in the plan, geometrical system one and four is parallel to Shah Mosque (refer to Table 7.40& Table D-7 of Appendix D and Table 6.14).

Table 7.40: General analysis of *ivans* in high Mughal case studies (Author-2012)

	mosque	shape	dimension			Elements of *Ivan "screen"*											material	relation		Location of the facade			Geometrical patterns	
			L	W	H	1	2	3	4	5	6	7	8	9	10	11		nave	Mughsura	front	back	flat	Plan	Façade
West Ivan	Taj Mahal Mosque	rectangular	21.5	7	23		✓	✓	✓	*	✓		✓	✓		✓	Marble and sand stone		✓			✓	4	1,4
West Ivan	Delhi Jami Mosque	rectangular	14.5	7.5	22		✓	✓	✓	✓			✓			✓	White marble & red sand stone	-	✓	✓			3,4	1,2,5
	East *ivan* of Delhi Jami Mosque	rectangular	19	10.5	25		✓	✓	✓	*		✓	✓			✓	Red sand stone	corridors	-	✓			1,4	1,2,5
	North and south *ivan* of Delhi jami Mosque	rectangular	12.3	5	20		✓	✓	✓	*		✓	✓			✓	Red sand stone	corridors	-	✓			1,4	1,2,4

element of *Ivan* screen

1.inscription frieze
2.spandrel
3.band
4.plinth
5.minaret
6.scroll
7.blind arcade
8.open arcade
9.muqarnas
10.squnch net
11.parapet

7.5.2.Domed Chamber

7.5.2.1. Form

Square pattern that was applied earlier in Timurid, Safavid and early Mughal, used in both high Mughal case studies.

7.5.2.2. Relations of Domed Chamber

The relational pattern of domed chamber with other spaces cannot be matched with Safavid pattern and completely diverse, it was complete symmetrical in all sides. In the center of each side, one vault tunnel can be seen to behind spaces; the west one was regarded for *mirab* (see Figure 44).

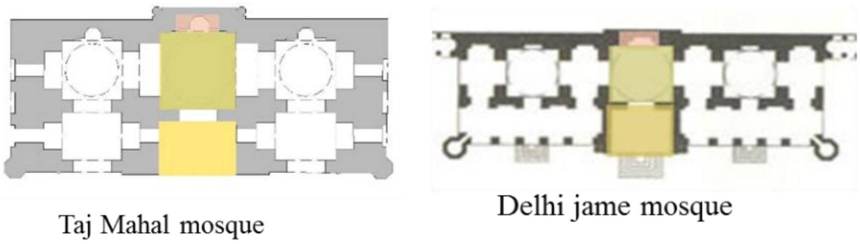


Figure 7.45: Combination domed chamber, *ivan, mihrab*(Author-2013)

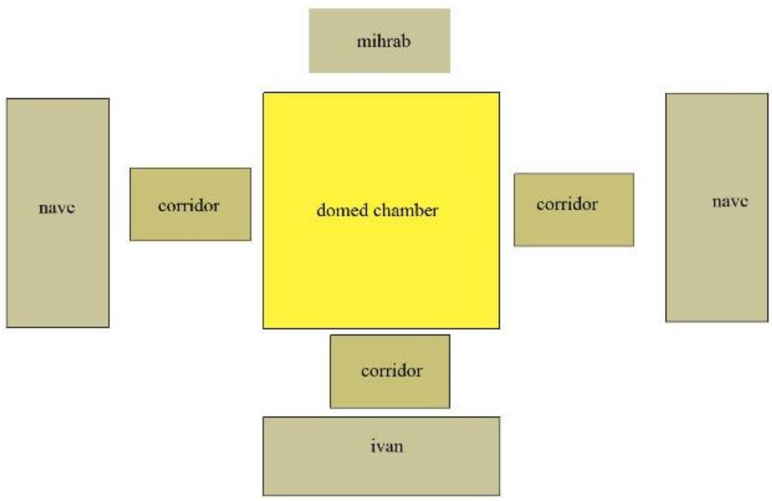


Figure 7.44: Organization and relation with other spaces of domed chambers (Author-2013)

7.5.2.3. Combination of Domed chamber, Ivan & mihrab

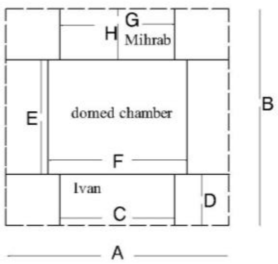
This powerful pattern was used in all Timurid and Safavid; Mughal case studies (see Figure 7.44).

7.5.2.4. Proportion between Domed chamber, Ivan and Mihrab

Table D-6& Table D-8 (in the Appendix D) , Table 7.47 shows geometrical analysis of Taj Mahal and Delhi Jami Mosques based on Persian geometrical system and Table 7.41 represents the proportion of this mosque based on results of Table D-5 & Table D-6 in the Appendix D. Then the revised results that display in Table 7.42, were compared with proportions of Timurid domed chambers (refer to Table 7.31). These points can be regarded: more compatibility with shah mosque can be comprehended in Taj mahal mosque as earlier high Mughal case studies , this similarity is the ratio length- to- width of whole combination , the ratio length- to- width of *gibla ivan* . In addition, just one likeness can be understood for Delhi Jami mosque in the ratio of length- to- width of *mihrab.*

Table 7.41: Horizontal proportions of combination domed chamber, *Ivan* and *mihrab* based on Persian geometrical systems (Author-2013)

name of mosque	A	B	C	D	E	F	G	H
Taj mahal mosque	$(\frac{\sqrt{2}}{4}+\frac{2}{\sqrt{5}}+1)a$	$(2/\sqrt{5}+1)a$	a	$\sqrt{2}/2\ a$	a	a	$1/\sqrt{5}$ a	$1/2\sqrt{5}$ a
Delhi Jami mosque	$\sqrt{3}a(1+\frac{1}{\sqrt{5}})$	$\sqrt{3}a$	a	$2/\sqrt{5}a$	a	a	$1/\sqrt{5}$ a	$\sqrt{2}/8\ a$



Key of Table 7.41

Table 7.42: Horizontal proportions of combination domed chamber, *ivan* and *mihrab* (Author-2013)

name of mosque	combination Ivan+ domed chamber+ Mihrab			Ivan		domed chamber		Mihrab	
	length	width	length /width	length	width	length	width	length	width
Taj mahal mosque	2.25	1.9A	1.2	A	0.7A	A	A	0.54A	0.2A
Delhi Jami mosque	2.5A	1.7A	1.5	A	0.9A	A	A	0.45A	0.2A

7.5.2.5. Windows

In contrast of Shah Mosque, none of high Mughal case studies have any windows in domed chamber, so that for avoiding get dark space, the height of vault tunnels increased heavily (refer to Table 6.24 & Table 6.29).

7.5.2.6. Material

Material is commonly related to climate and geographical conditions such as material in both high Mughal phase that is dissimilar to Safavid case study. Domed chamber in Both of these mosque covered by red sand stone and elaborated with white marble for floral patterns(refer to Table 6.24 & Table 6.29).

7.5.2.7. Load Bearing System

The load bearing of high Mughal case studies unlike Safavid one , comprised one horizontal level and one big vault tunnel without blind arch(the floral pattern replaced it), so that these get simpler than domed chamber of Shah mosque(see Table 7.47, Figure 7.46).

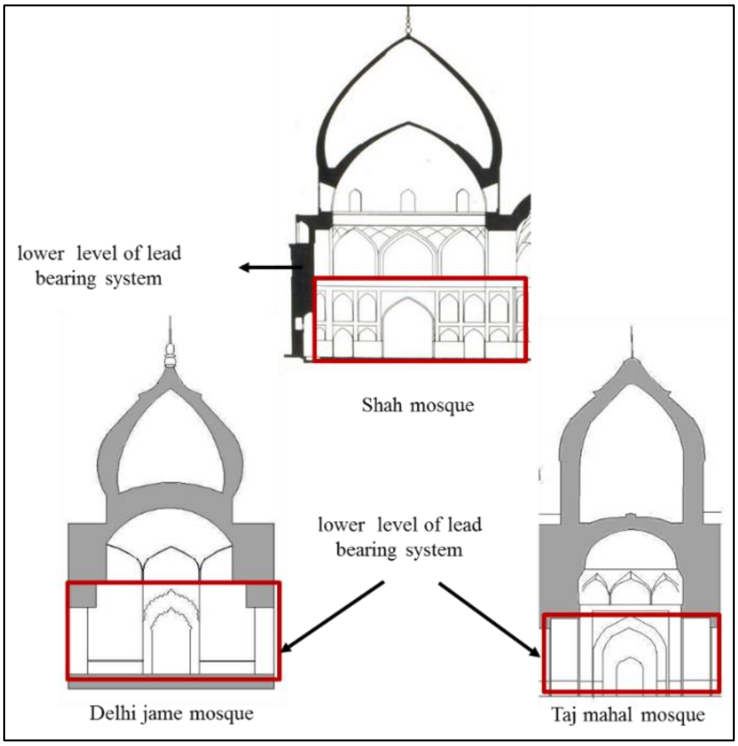


Figure 7.46: Load bearing system (Author.2013)

7.5.2.8. Transitional System

The transitional system of Taj Mahal mosque is more similar to Shah Mosque in compared with Delhi Jami mosque. The first mosque has two clear horizontal band in top and down of transitional system, but the later mosque only has down level and from the up side combined with internal dome. The former mosque like Shah Mosque was used arch-net for linking the eight main arch of transition system. Both of high Mughal cases have similar *squinch* with Shah Mosque (see Table 7.47and Figure 7.47).

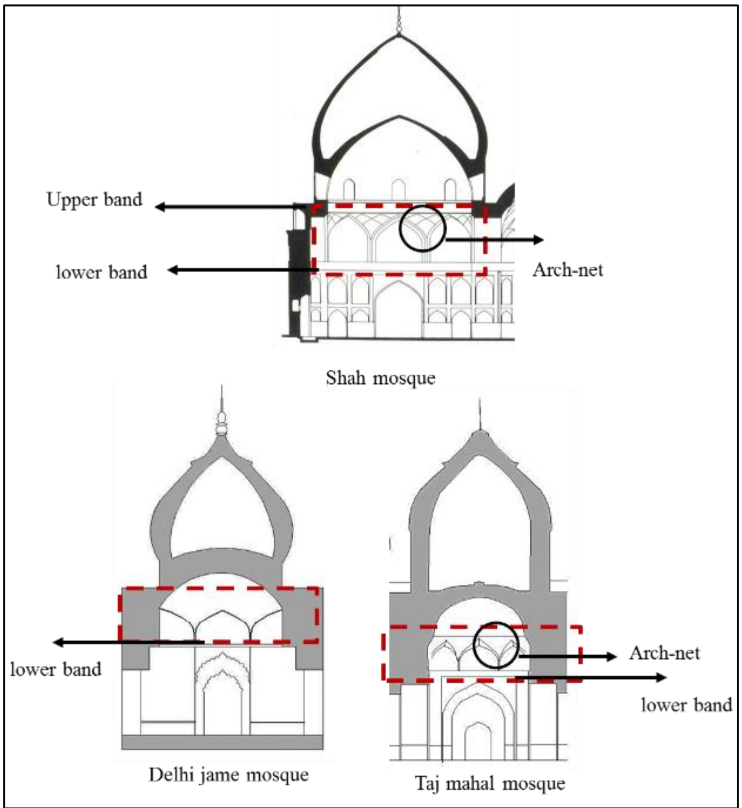


Figure 7.47: Transitional system (Author-2013)

7.5.2.9. Geometrical System of Domed Chamber

With regard to Table D-7 & Table D-8 (in the Appendix D) , Table 7.47 show using Persian geometrical systems in both façade and plan of internal domed chamber of Shah Mosque .with comparison these tables and Table 6.15, this points can be seen. More similarity can be seen in the plan with applying geometrical system one and four, it can't be realized in the façade, only geometrical system eight was used for both Taj Mahal and Shah Mosques (Figure 7.48).

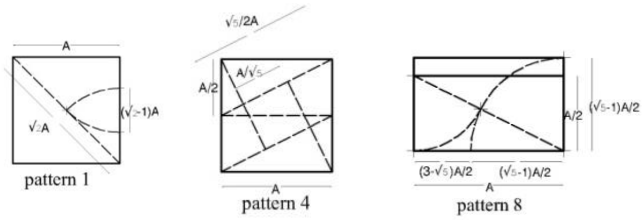


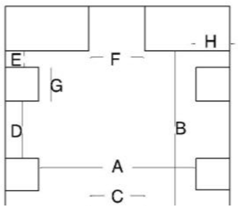
Figure 0.2: Useful geometrical patterns in domed chamber of high Mughal mosques (Author-2013)

7.5.2.10. Horizontal Proportion of Domed Chamber

Table 7.43 shows horizontal proportion of domed chamber based on Persian geometrical systems (refer to Table D-7 & Table D-8 in the Appendix D). Then results were summarized in Table . In terms of horizontal proportions of Safavid domed chambers, it was observed these points based on Table 7.44 &Table 7.33 : The horizontal proportions of high Mughal mosques are less matched with Shah Mosque, because of difference in relational patterns between Safavid and high Mughal mosque that explained before. In the mosque of Delhi, the similarity only can be seen in the ratios of *mihrab*, entrance and vault tunnel to nave.

Table 7.43: Horizontal proportions of domed chambers based on Persian geometrical systems (Author)

	A	B	C	D	E	F	G	H
Taj mahal Mosque	a	a	$\sqrt{2}/2\ a$	$\sqrt{2}/2\ a$	-	$\sqrt{2}/2\ a$	$(2\text{-}\sqrt{2})a/4$	$\sqrt{2}/4\ a$
Delhi Jami Mosque	a	a	a/$\sqrt{5}$	a/$\sqrt{5}$	-	a/$\sqrt{5}$	$(1\text{-}1/\sqrt{5})a$	$(1\text{-}1/\sqrt{5})a$



Key of Table 7.43

Table 7.44: Horizontal proportions of domed chambers (Author-2013)

name of mosque	length	width	entrance	main vaulted tunnel	secondary vaulted tunnel	*Mihrab*	length of wall between corridors	thickness
Taj mahal Mosque	A	A	0.7A	0.7A	-	0.7A	0.15A	0.35A
Delhi Jami Mosque	A	A	0.45A	0.45A	-	0.45A	0.3A	0.3A

7.5.2.11. Vertical Proportion of Domed Chamber

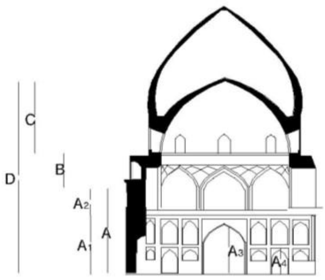
As similar the process in horizontal proportions, the results that were achieved (firstly from Table D-7& Table D-8 of Appendix D and then Table 7.45) represents in Table 7.46

. In comparison between these results and Table 7.35 (Safavid vertical proportions).these points can be regarded:

- Among the vertical proportions of Taj mahal mosque's domed chamber, only the height of internal dome and total height of domed chamber are near to Shah mosque. These ratios in the Delhi Jami mosque is incompatible with Safavid case study.
- The proportions of lead bearing and transitional systems of both Mughal case studies can't be matched with Safavid ones due to the lack of identical form in these two systems, in comparison with Shah Mosque.
- The height of transitional system decreased and the height of lead bearing system increased specially in Taj mahal and then in Delhi Jami mosque.

Table 7.45: Vertical proportions of domed chambers based on Persian geometrical system (Author-2013)

name of mosque	A	A_1	A_2	A_3	A_4	B	C	D
Taj Mahal Mosque	$2a/\sqrt{5}$	$2a/\sqrt{5}$	-	$(2\sqrt{5}-1)a/2\sqrt{5}$	-	$(2\sqrt{5}-3)a/2\sqrt{5}$	$(8a-\sqrt{5})/2\sqrt{5}$	$((2+\sqrt{5})a-1)/2$
Delhi Mosque	$(4-\sqrt{2})a/4$	$(4-\sqrt{2})a/4$	-	$a/\sqrt{5}$	-	$(2\sqrt{3}+\sqrt{2}-4)a/4$	$(\sqrt{2}-2\sqrt{3}+3)a/4$	$(3+\sqrt{2})\,a/4$



Key to Table 7.45

Table 7.46: Vertical proportions of domed chambers (Author-2013)

name of mosque	load bearing					transition tier	internal dome	domed chamber
	load bearing	lower section	upper section	main corridor	secondary corridor			
Taj mahal Mosque	0.9A	0.9A	-	0.75A	-	0.3A	0.65A	1.6A
Delhi Jami Mosque	0.65A	0.65A	-	0.45A	-	0.2A	0.25A	1.1A

Table 7.47: General analysis of domed chamber in high Mughal case studies (Author-2012)

Domed chamber	**shape**	**dimension**			**Elements of internal facade**							**relation**			**opening**	**material**	**Geometrical pattern**	
					Load bearing		Transition section										plan	Façade
		L	W	H	1	2	1	2	3	4	5	*Ivan*	nave	*Mihrab*				
Taj Mahal Mosque	Square	11	11	18	2	3	✓			✓	✓	✓	✓	✓	_	Red sand stone	1,4	1,4,8
Delhi Jami Mosque	Square	9.5	9.5	12.5	2	3	✓		✓			✓	✓	✓	_	Red sand stone	1,3,4	1,2,4

load bearing system
1.blind arcade
2.open arcade

transition system
1.squinch
2.pendative
3.recumbent arch
4.arch-net (*squinch*-net)
5.muqarnas

7.5.3. Double Dome

In contrast, of early Mughal case study, both of high Mughal mosque have designed based on Discontinuous double dome. Jami mosque of Delhi is congressional mosque and mosque of Taj Mahal is a little part of Taj Mahal complex, so that the first one has bigger and higher domes. One of main characteristics of Mughal mosques is that division prayer hall to three parts and using three domes above each part, the central dome is bigger than the others are. Table 7.48 presents the general features of domes in high Mughal case studies.

Table 7.48: General analysis of double domes high Mughal case studies (Author-2013)

Name of mosque		**Supporting system**	**Transition tier**	**C****	**Type of internal shell**		**Type of external shell**		**drum**	**material**	
					type	H*	type	H*	type	outer	inner
Taj Mahal Mosque	**Discontinuous double dome**	Square with bearing wall	*Squinch +muqarnas*	31	Circular	18	Bulbous	36.5	Cylinder	White marble	Red sand stone
		Square with bearing wall	*Squinch +muqarnas*	23.5	Circular	15	Bulbous	30			
Delhi Jami Mosque		Square with bearing wall	*Squinch*	38	Circular	12.5	Bulbous	29.5			
		Square with bearing wall	*Squinch*	30	Circular	9.7	Bulbous	23			

7.5.3.1. External Shell

Taj Mahal Mosque and Delhi Jami Mosque have bulbous type of external shell. that is similar to Shah Mosque with some difference in proportions (Table 7.48).

7.5.3.2. Proportion of External Shell

With concerning Table 7.49&Table 7.41 and Figure 7.49, generally the proportions of Taj Mahal Mosque is more analogous to Shah Mosque than Delhi Jami Mosque, exception in the height of upper arch (H_2). In addition, most of the proportions of Delhi Jami Mosque decreased in comparison to Shah and Taj Mahal Mosques.

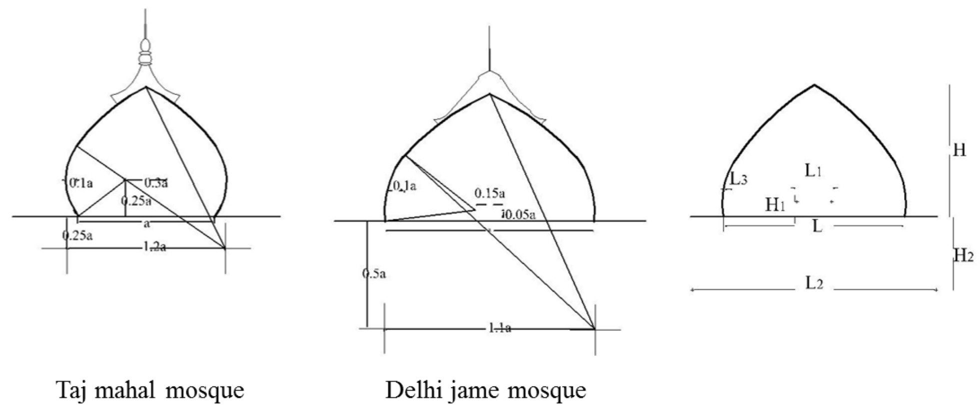


Figure 7.49: External shell of double domes in high Mughal case studies (Author-2013)

Table 7.49: Proportion of external shell of double domes in high Mughal case studies (Author-2013)

Name of mosque	Bulbous dome					
	L_1	H_1	L_2	H_2	L_3	H
Taj Mahal Mosque	0.3a	0.25a	1.2a	0.25a	0.1a	0.8a
Delhi Jami Mosque	0.15a	0.05a	1.1a	0.5a	0.1a	0.6a

7.5.3.3. Internal Shell

Unlike the Safavid mosque that have pointed type, both high Mughal case studies have circular type for internal shell (refer to Figure 7.50).

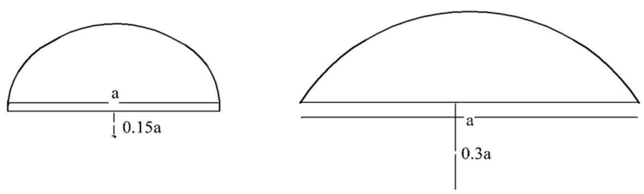


Figure 7.50: Internal shell of double domes in high Mughal case studies (Author-2013)

7.5.3.4. Drum

Drum, like shah mosque, is cylinder in both high Mughal mosques.

7.5.3.5. Material

The material cannot be match with Shah Mosque, the domes of high Mughal ones were covered by white marble externally and red sand stone internally.

7.5.3.6. Thickness

Similar to the Safavid case study, the thickness of both internal and external shells gradually reduced from the base to the top of dome.

7.5.4. Squinch

With regard to Table 7.50 &6.17 about *squinch* , both high Mughal case studies followed shah mosque in using groined vault as *squinch* , but the *squinch* of first one (mosque of Taj Mahal) elaborated with *muqarnas* as additional revetment .

Table 0.3: General analysis of *squinch* in high Mughal case studies (Author-2013)

Name of mosque	**type**	**material**	**position**		
			Ivan	dome	entrance
Taj Mahal Mosque	Groined vault with revetment of muqarnas	Red sand stone	-	✓	-
Delhi Jami Mosque	Groined vault	Red sand stone	-	✓	-
	Groined vault	Red sand stone			East entrance

7.5.5. Pointed Arch

With regard to Table 7.51and Table 6.18, the arch of Taj mahal mosque have high match with Shah mosque in using arch type 3-1 (*Panj-O Haft*) for inside and outside. But in the

Delhi Jami mosque, few space have Persian arch (arch type 3-2 that is in the same category with arch type 3-1) such as south , north and east gateways and *ivans* .Most of the arches are cusped that belong to Indian arch .

Table 7.51: General analysis of pointed arch in High Mughal case studies (Author-2013)

	Name of mosque	type					Position										
							Inside				Outside						
		3-1	**3-2**	**4-1**	**6-1**	**6-1**	Domed chamber	*Mihrab*	nave	corridors	West *Ivan*	East *Ivan*	North and south Ivan	Court yard	South entrance	North entrance	East entrance
1	Taj Mahal Mosque		✓				×										
2		✓					×										
3		✓						×									
4		✓									×						
5		✓												×			
6	Delhi Jami Mosque		✓									×					
7			✓										×				
8			✓												×		
9			✓													×	
10			✓														×

7.5.6. Main Findings of Safavid Architectural Elements in High Mughal Case Studies

Table 7.52presents the main finding of Safavid architectural elements in high Mughal case studies (Taj mahal and Delhi Jami Mosques) based on five Persian mosque elements (Ivan, domed chamber, double dome, *squinch*, and pointed arch).

Table 7.52: Level of similarity between Safavid and high Mughal case studies (Author-2013)

element	feature	Similarity Shah mosque with Taj Mahal Mosque: None	Taj Mahal Mosque: Moderate	Taj Mahal Mosque: High	Delhi Jami Mosque: None	Delhi Jami Mosque: Moderate	Delhi Jami Mosque: High	Description
Pointed arch	Type of big spaces			✓		✓		
	Type of small spaces			✓		✓		
squinch	Type		✓				✓	
	Material	✓			✓			
Double dome	External shell			✓			✓	
	Internal shell	✓			✓			
	Proportion of external shell			✓		✓		The proportions Taj mahal mosque is more analogous to Shah Mosque exception in the height of upper arch (H_2).
	Drum			✓			✓	
	Thickness			✓			✓	
	Material	✓			✓			
Ivan	Number	✓					✓	
	Relation of *qibla ivan*			✓	✓			
	Relation of other *ivans*	-	-	-	✓			
	Placement			✓	✓			
	Structure of ceiling			✓			✓	
	Material	✓			✓			
	Qibla ivan façade		✓			✓		
	Other ivan 's facade	-	-	-	✓			
	Persian geometrical systemsof *qibla ivan*		✓		✓			Persian geometrical systems in the facade
			✓			✓		Persian geometrical systems in the plan
	Persian geometrical systems of other *ivans*	-	-	-		✓		Persian geometrical systems in the facade
		-	-	-		✓		Persian geometrical systems in the plan
element	feature	Similarity Shah mosque with Taj mahal Mosque			Delhi Jami Mosque			Description

		None	Moderate	High	None	Moderate	High	
Ivan	Proportions of *gibla ivan*		✓				✓	
	Proportions of other *ivans*	-	-	-	✓			
Domed chamber	Form			✓			✓	
	Relation	✓			✓			
	Combination domed chamber *ivan, mihrab*			✓			✓	
	Compositional pattern of negative and positive arches			✓			✓	
	load bearing system	✓			✓			
	Transitional system			✓		✓		
	windows	✓			✓			
	Material	✓			✓			
	Geometrical system	✓			✓			Persian Geometrical patterns in the façade
			✓			✓		Persian Geometrical patterns in the plan
	Proportions		✓		✓			Proportion between domed chamber, *ivan, mihrab*
		✓			✓			Proportions in horizontal elements
			✓			✓		Proportions in vertical elements
		✓					✓	*Mihrab* proportion

7.6. Phase Three: Comparison between Early and High Mughal Case Studies

This phase of chapter result and discussions specified to comparison between early and high phase of Mughal case studies in order to the evolution and alteration of Timurid architectural elements , the outcome shows that which of these elements changed and combined with Mughal architecture or applied in the original phase.

Table 7.53 represents the level of similarity with Timurid architecture directly and indirectly, direct similarity with Timurid architecture in early Mughal case study and indirect similarity via Safavid architecture in high Mughal case studies.

The regarding point is that some feature of Timurid architectural elements didn't continue in Safavid case study and so that it can' be find in high Mughal case studies .this characteristic must be omitted including :

- The type of pointed arch for small spaces
- Material of *squinch*
- Material of double dome structure of ceiling in *ivans*
- Material of *ivans*
- Material of domed chamber

Table 7.53: Level of similarity between high Mughal case studies (Author-2013)

Element	Feature	**Fatehpur Sikir Mosque**	Level of similarity with Timurid	**Taj Mahl Mosque**	Level of similarity with Safavid	**Delhi Jami Mosque**	Level of similarity with Safavid
Pointed arch	Type of big spaces	Arch type 4	**H**	Arch type 4	**H**	Arch type 4,5	**M**
	Type of small spaces	Arch type 4	**N**	_	-	-	-
Squinch	Type	-Groined vault with revetment of arch-net, -Groined vault , -A beam with revetment of arch-net	**H**	Groined vault with revetment of muqarnas	**M**	Groined vault	**H**
	Material	Sand stone and mosaic faience	**N**	-	-	-	-
Double dome	External shell	-	-	Bulbous dome	**H**	Bulbous dome	**H**
	Internal shell	-	-	Circular	**N**	Circular	**N**
	Proportion of external shell	-	-	Similar to shah mosque	**H**	Similar with decrease all dimension	**M**
	Drum	-	-	cylinder	**H**	cylinder	**H**
	Thickness	-	-	Decrease from the base to top	**H**	Decrease from the base to top	**H**
Ivan	Number	three *ivans*	**N**	One *ivan*	**N**	Four *ivan*	**H**
	Form	Rectangular	**H**	Rectangular	**H**	Rectangular	**H**
	Relation of *qibla ivan*	Similar to Mir chakhmaq with some change	**M**	Similar shah mosque	**H**		**N**
	Relation of other *ivans*	Similar Gihar shad mosque	**H**	-	**-**		**N**
	Placement to façade	Flat to façade(east)	**H**	in the line with behind spaces	**H**	In front of behind spaces (all *ivans)*	**N**
		In front of facade (others)	**N**				
	Structure of ceiling	Semi dome (west)	**N**	-	-	-	-
		Vaulted tunnels (others)	**H**				
	Material	Red sand stone	**N**	-	-	-	-
	Qibla ivan façade	Open arch, frieze , band , spandrel Similar Goharshad	**M**	Open arch , band , spandrel , plinth , *muqarnas*	**M**	Open arch , band , spandrel, minaret , band	**M**

Element	Feature	**Fatehpur Sikir Mosque**	Level of similarity with Timurid	**Taj Mahl Mosque**	Level of similarity with Safavid	**Delhi Jami Mosque**	Level of similarity with Safavid
Ivan	Other ivan ‘s facade	Open arch, frieze , band , spandrel	**M**	-	-		**N**
	Geometrical systems in façade (*gibla ivan)*	Pattern 2,5	**M**	Pattern 1	**M**		**N**
	Geometrical systems in plan (*gibla ivan)*	Pattern 3,4	**H**	Pattern 1,4	**M**	Pattern 4	**M**
	Geometrical systems in façade (others)	Pattern 1,2	**M**	-	-	Pattern 1	**M**
	Geometrical systems in plan (others)	Pattern 4	**M**	-	-	Pattern 1,4	**M**
	Proportions of *gibla ivan*	Ration of length to width and height and height of dome (similar to Gohar shad	**H**	Ratio of length to width and height	**M**	Ratio of length to width and height and height of minaret	**H**
	Proportions of others		**N**	-	-		**N**
Domed chamber	Form	Square	**H**	Square	**H**	Square	**H**
	Relation domed chamber with nave and *ivan*	With three vaulted tunnel near like withMir chakhamq	**M**	With one vaulted tunnel	**N**	With one vaulted tunnel	**N**
	Combination domed chamber , *ivan , mihrab*		**H**		**H**		**H**
	Load bearing system	Like Mir chakhmaq with some change	**M**		**N**		**N**
	Compositional pattern of load bearing system	Three negative arches and one positive arch	**H**	Three negative arches and one positive arch	**H**	Three negative arches and one positive arch	**H**
	Transitional system	Like Mir chakhmaq with some change	**M**	Similar to Shah mosque	**H**		**N**
	Material	red sand stone and mosaic faience	**N**	-	-	-	-
	Windows	Similar to Torbat jam mosque	**H**	With out	**N**	With out	**N**

Element	Feature	**Fatehpur Sikir mosque**	Level of similarity with Timurid	**Taj Mahl Mosque**	Level of similarity with Safavid	**Delhi Jami Mosque**	Level of similarity with Safavid
Domed chamber	Proportion of length to width for combinational spaces	Length /width=1.5	**H**	Length /width=1.2	**H**	Length /width=1.5	**N**
	Mihrab proportions		**N**		**N**		**N**
	Horizontal Proportion	Identical size of negative and positive arch	**M**		**N**		**N**
	Vertical proportion	Overall height. height of internal dome	**M**	Overall height. height of internal dome	**M**		**N**
	Geometrical system in façade		**N**		**N**		**N**
	Geometrical system in plan	Pattern 4	**M**	Pattern 1,4	**M**	Pattern 4	**M**

H: high
M: moderate
N: none

7.7. Summary

7.7.1. Phase One: The Comparison between Timurid Case Studies

Based on Table 7.54, between functional elements, domed chamber in all Timurid case studies have more similarity than *ivan*. Among formal elements, pointed arch has more analogous in comparison to double dome and *squinch*.

Table 7.54: Summery of level of similarity between Timurid case studies (Author-2013)

	High level of similarity between case studies	**Moderate level of similarity between case studies**
Domed chamber	Combination with *Mihrab* and south *ivan* Relation with naves Material Proportions Use Persian geometrical system Commotional pattern of positive and negative arch	Shape Relation with south *ivan* Transitional system windows
Ivans	Shape Structure Proportions Use Persian geometrical system	Number of *ivans* Size of south *ivan* Material Façade
Double dome	General type Drum Material Thickness	Type of external shell Type of eternal shell
Squinch	Additional ornamentation in the surface	Type of *squinch*
Pointed arch	Type of arch for covering big space	Type of arch for covering small space

7.7.2. Phase Two: The Comparison between Timurid and Mughal Case studies Directly and Indirectly

7.7.2.1. Level one: direct Timruid influence in early Mughal mosques:

Table 7.55 represents the different level of similarity of early Mughal period with Timurid architecture. Formal elements such as pointed arch and *squinch* have more parallel than functional elements. Transitional and load bearing system of domed chambers, geometrical system and elements of façade in *Ivan* have combinational face between Mughal and Timurid architecture.

Table 7.55: Summery of level of similarity between Timurid and early Mughal case studies (Author-2013)

	High similarity with all Timurid cases	High similarity with one Timurid cases	Moderate similarly
Domed chamber	Form Relation with naves Combination with *mihrab* and *ivan* Commotional pattern of positive and negative arch Use Persian geometrical systems	Type and size of vaulted tunnel to nave windows	load bearing system transitional system
Ivans	Placement of east façade to behind spaces Form Structure of ceiling east and south *ivans* Geometrical systems in plan	Relation of south and east *ivans* with other spaces Proportion (height of dome) The ratio of length to width and height	Relation of west *ivan* with other behind spaces *Qibla ivan* façade Other *ivans* façade Geometrical system in façade
Squinch	Type of *squinch*	_	_
Pointed arch	Type of arch for big spaces	_	_

In conclusion, the Fatehpur siskri mosque in each Persian architectural elements influenced from one or two Timurid case studies more than other case studies such as:

- Domed chamber: Most similarity with Mir Chakhmaq Mosque& Torbat Jam Mosque
- Ivan: Most similarity with Mir Chakhmaq and Goharshad Mosque *Sqiunch*: Most similarity with Mir Chakhmaq and Goharshad Mosques
- Pointed arch: similarity with all Timurid case studies

7.7.2.2. Level two: direct Timruid influence in Safavid mosque:

With regard to Table 7.56, both functional element of Shah Mosque as Safavid case study compatible with Timurid architecture. Only pointed arch have less similarity with Timurid architecture in comparison with other formal elements (double demand *squinch)*.

In conclusion, the shah mosque in each Persian architectural elements influenced from one or two Timurid case studies more than others:

- Domed chamber: Most similarity with Mir Chakhmaq Mosque& Torbat Jam Mosque
- Ivan: Most similarity with Goharshad Mosque
- Double dome : Most similarity with Goharshad Mosque
- *Sqiunch*: Most similarity with Mir Chakhmaq Mosque
- Pointed arch: similarity with all Timurid case studies

Table 7.56: Summery of level of similarity between Safavid and Timurid case studies (Author-2013)

	High similarity with all Timurid cases	High similarity with one Timurid cases	Moderate similarly
Domed chamber	Form Relation Combination with *mihrab* and *ivan* Transitional system Use Persian geometrical systems Commotional pattern of positive and negative arch	Load bearing system Proportions and ratio	windows
Ivans	Number Relation with other spaces Placement to beind façade Form Proportions and ratio Structure Use Persian geometrical systems(south ivan)	Use Persian geometrical systems(other ivans)	South ivan ‘s façade Other ivans ‘s façade
Double dome	Drum Thickness	Type of external shell Proportions and ratio	Type of internal shell
Squinch	_	_	Type of *squinch*
Pointed arch	Type of arch for big spaces	_	_

7.7.2.3. Level three: indirect Timruid influence in high Mughal mosques via Safavid architecture:

With regard to Table 7.57, among formal elements, double dome and *squinch* have more similarity with Safavid case study, exception in proportions of late High Mughal case studies that was merged with Mughal architecture and then, pointed arch gradually combined with Mughal architecture from the first to late high Mughal case studies.

Between functional elements, domed chamber, in contrast *Ivan*, can be realized identical manner (high and medium similarity from both high Mughal case studies). Both of these elements have combined with Safavid and Mughal architecture.

Table 7.57: Summery of level of similarity between Safavid and high Mughal case studies (Author-2013)

	High level of Safavid Similarity with both high Mughal case studies	**High level of Safavid Similarity with one high Mughal case study**	**Medium level of Safavid Similarity with both high Mughal case studies**	**Medium level of Safavid Similarity with one high Mughal case study**
Domed chamber	Form Combination domed chamber *ivan, mihrab* Compositional pattern in negative and positive arches	Transitional system(HMCS1) *Mihrab* proportion (HMCS2) ○	Geometrical patterns in the plan vertical Proportions	Transitional system(HMCS2) Proportion between domed chamber, *ivan*, *mihrab*(HMCS1)
Ivans	Structure of ceiling	Number (HMCS2) Relation of *qibla ivan*(HMCS1) Placement to façade(HMCS1) Proportions of *gibla ivan* (HMCS2)	*Qibla ivan* ‘s façade geometrical pattern of *qibla ivan*(plan)	geometrical pattern of *qibla ivan*(façade) (HMCS1) geometrical pattern of *other ivans* (façade) (HMCS2) Proportions of *gibla ivan* (HMCS1)
Double dome	External shell Thickness Drum	Proportion of external shell(HMCS1)	–	Proportion of external shell(HMCS2)
Squinch	–	Type of *squinch*(HMCS2)	–	Type of *squinch*(HMCS1)
Pointed arch	–	Type of arch for small spaces(HMCS1) Type of arch for big spaces (HMCS1)	–	Type of arch for small spaces(HMCS2) Type of arch for big spaces (HMCS2)

HMSC1: first high Mughal case study (Taj Mahal Mosque)
HMSC2: second high Mughal case study (Delhi Jami Mosque)

7.7.3. Phase Three: Comparison between Early and High Mughal Case Studies

Among the five Timurid architectural elements, formal elements including pointed arch, *squinch* and domed chamber could be used in near original face with less change. Domed chamber and *Ivan* as functional elements were needed to match with Mughal mosques due to different combination between Timurid and Mughal mosques. Generally, in functional elements, material, façade elements, proportions of façade less can be matched with Timurid architecture as foreigner styles.

Below, the summary of influence from Timurid in whole Mughal period (early and high phases) is given.

7.7.3.1.Domed chamber

- In the both early and high Mughal period**,** high similarity with Timurid architecture can be realized in form, compositional pattern of negative and positive arch, combination of domed chamber with *Ivan* and *mihrab*, in addition geometrical system in plan with medium analogous.
- Other features of Timurid architecture such as horizontal proportions, windows and load bearing system, relation of domed chamber with naves and *qibla iwan* only can be seen in early Mughal period.
- Among proportions, ratio of length- to- width in combination (domed chamber, Ivan and *mihrab*) completely matched with Fatehpur sikri and Taj mahal mosques.
- In contrast Fatehpur sikri and Taj mahal mosques, the Delhi Jami mosque as one of symbol of apex Mughal mosque, none of these characteristics matched with Timurid and safavid architecture, these feature comprise: transitional system, vertical proportions.

- Proportion of *mihrab,* geometrical system in façade, material weren't influence in none of early and high Mughal period.

7.7.3.2. Ivan

- Among the Mughal case studies, only Delhi Jami mosque was followed four *Ivan* mosque with courtyard as Timurid typical pattern. Exception form of *Ivan,* none of other characteristic of Ivan could not be coincident with Timurid *ivans.*
- Even though high similarity with Timurid for early Mughal period can be seen in these features: geometrical system in plan, proportions of *gibla ivans* and relation of other *ivans* with behind spaces.
- The relation with other spaces ,the location to the facade , the façade elements and proportions of other *ivans,* the geometrical systems of *gibla ivan* are dissimilar from Timurid and safavid models in Delhi Jami mosque ,in contrast with Fatehpur sikri and Taj mahal mosques.
- Among the Timurid geometrical systems, the similarities can be seen firstly in the plan and then in the façade, and most of these similar systems used in the west Ivan in comparison other *ivans*. Geometrical system four and then one with the square base are the most useful in Mughal mosques.
- In general, proportions of west *Ivan* or *gibla Ivan* could be matched with Timurid and safavid *Ivan* model , the main reason for this similarity is the combination west *ivan* with domed chamber like Timurid and Safavid .Even though , Other *ivans* were merged with big gateways and have diverse blends. So that, the elements of façade in west *Ivan* are mixture of more Timurid with Mughal architecture.

7.7.3.3. Double dome

- This Timurid element could not be influenced in early Mughal period and it was transferred via Safavid architecture in high Mughal phase, it can be seen in both high Mughal case studies.
- Most of Timurid features can be found in these especially in Taj mahal mosque and only the proportions of Taj mahal mosque matched with Timurid double domes.

7.7.3.4. Squinch

- The Timurid formal element could be applied in basic face with low alteration, diverse type of squinch used in the early Mughal period, however only Timurid typical type (groined vaults) can be found in the early (some domes and semi domes) and high (all domes and semi domes) Mughal period.

7.7.3.5. Pointed arch

- In the two first Mughal case studies, the arch type 3-1 (Panj –O Haft) was applied for all big spaces like Timurid and also Safavid architecture, in the Delhi Jami Mosque, moreover arch type 3-1 and arch type 3-2 (from one category with 3-1), using cusped arch as typical Mughal arch type can be seen greatly in many spaces.

CHAPTER 8: RESEARCH CONCLUSION AND FUTURE WORKS

8.1. Conclusion

This research represents the Timurid architectural influence in Mughal mosques. Despite the fact that the Mughal period (1526-1707AD) in India was a contemporary of the Safavid (1524_-1736AD) in Persia, many historical evidences indicated that Mughal architecture was mostly influenced by the Timurid dynasty (1370-1526) more than Safavid architecture, and the fact that Timurid architecture was prototype for both of Safavid and Mughal styles. This research focuses on the transfer of Timurid architectural elements to those that were innovated and inserted to the mosques of Persia by Persian master builders. These elements may be innovated in Timurid period or developed and used from the pre-Timurid era.

Firstly, by finding the historical evidences, the routes and channels of Timurid influence in Mughal mosques were examined in objective one. The selection of case studies from valid routes is a suitable strategy is the next step. Five Persian architectural elements in Timurid mosques were identified in objective two, and then the results of Timurid elements were examined in Mughal mosques in three levels based on the valid routes of the first objective (objective three). Finally, the evolution of Timurid impact in the whole of Mughal period (early and high phases) was studied in the course of objective four. Each objective is described below.

Objective one: To define and verify the routes of Timurid architectural influence in Mughal buildings of the Indian subcontinent with regards to Timurid (1370-1525AD) and Mughal (1526-1707AD) periods being non-concurrent.

The non-concurrence of both the Timurid and Mughal periods gave way to three assumptions with regards to the influence of Timurid architecture on Mughal buildings. The first proposition is via Indian dynasties that were a contemporary of Timurid, including the Delhi Sultanate (1193-1554AD) and the Deccan sultanate (1347-1678AD). The second is the direct influence from Timurid dynasty in Mughal buildings, while the third one is via Persian period's (Safavid) contemporary with Mughal buildings.

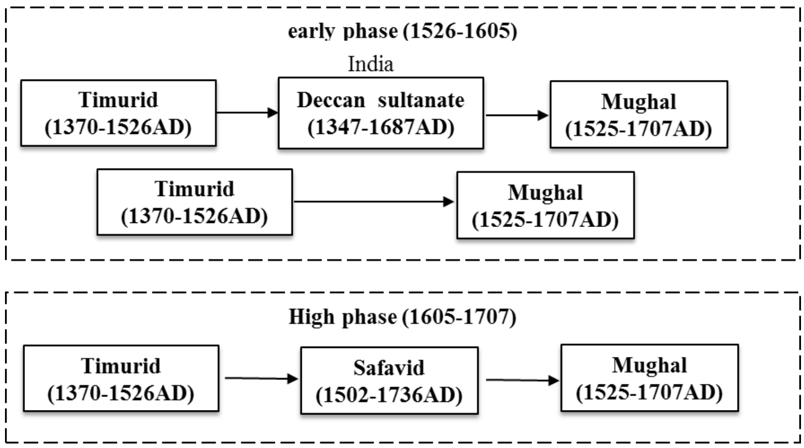


Figure 8.1: Distribution of Timurid influence directly and indirectly in Mughal architecture base on early and high phase (Author-2013)

In the early phase of the Mughal period and despite the good relationship between Mughal kings with the Safavid court. Timurid architecture was applied greatly in the early Mughal buildings due to two main reasons: firstly, in the initial phase of Mughal era, particularly Babur and Humayon. There was a limited amount of time to get acquainted with indigenous Indian styles, and Mughal kings were interested and ordered the migration of craftsman and architects of Persia (due to the fact that Babur was originally Timurid, and

Humayon spent an extended time living in Persia during the Akbar era). Another reason is that the initial phase of Mughal was a contemporary of the early phase of the Safavid dynasty, and the early Safavid period was completely influenced by Timurid architecture. Thus, Safavid architects and artisan that migrated to India were either Timurid architects still working in Safavid dynasty, or were new Safavid architects that preferred to apply Timurid elements and principles, so that instead of Safavid architecture, the Timurid one was transferred and influenced early Mughal buildings. The principles trend under Babur and Homayun were successfully merged into the great architectural synthesis under Akbar in the early Mughal phase.

Furthermore, among the Indian architectural periods that were affected by Timurid architecture, only the Delhi Sultanate (not Deccan Sultanate) heavily influenced the Mughal buildings of the early period, so that the first proposition (with omission of Deccan sultanate) and the second one are valid in the early phase of Mughal period (refer to Figure8.1).

In the high phase, the Mughal architecture reached a developmental peak, and has been heavily influenced from indigenous styles rather than foreign architecture. At the same time, Safavid architecture was in its climax of power and grandeur. The increase in relations between Mughal and Safavid in all aspects, such as politics, diplomacy, culture, literature, trade, and religion resulted in the use of Safavid architectural models in Mughal edifices. Safavid architects and craftsman that migrated to the Mughal court applied the rich and powerful Safavid architecture in the high Mughal period. With regards to the point that Safavid architecture generally continued Timurid principles in their buildings, the third proposition is valid during the high phase of Mughal (refer to Figure).

Objective 2: To identify the architectural elements that were originally Persian in the mosque of the Timurid period (1370-1525AD) in Iran.

Generally, compared to the three case studies of Timurid period, the domed chamber in all Timurid case studies are more similar than the *Ivan* between functional elements. Among the formal elements, the pointed arch is more analogous compared to the double dome and *squinch*. The results can be widely described in these terms:

- The high similarity of the domed chamber in Timurid samples can be seen in the combination and relation of domed chamber with behind spaces, type of material, and the usage of Persian geometrical systems (that mentioned in section 5.9.2); horizontal and vertical proportions.
- The high similarity of *Ivan* in Timurid case studies can be realized in shape and structure using Persian geometrical systems and horizontal and vertical proportions.
- Type of external (bulbous, pointed) and internal shell of double domes varies in Timurid case studies, but generally, the drum, material and thickness in a similar manner can be understood.
- One of the characteristics of the Timurid period is the usage of different types of *squinch*, and the Timurid case studies adhered to this manner. However, the additional ornamentation for the surface of all *squinches* remains similar.
- Type of pointed arch for covering big and high spaces is similar for all Timurid case studies (using arch type four - *Panj –O Haft Tond).*

Objective 3: To examine selected Mughal mosques of India (1526-1707AD) that have been influenced by Timurid architectural elements, with emphasis on Persian geometrical analysis for specific functional elements.

This objective needs to be answered in three levels according to the second and third propositions (described in Figure). The first level is the result of comparison between Timurid and early Mughal case studies; the second level is the results of comparison between Tmiurid and Safavid case studies; while the third is the results of the comparison between Safavid and high Mughal phases. Figure and Figure summarized the results of this objective.

Results of the early phase of Mughal period (first level):

Formal elements, such as pointed arch and *squinch* possess parallel than functional elements (domed chamber and *Ivan*).

- Among formal elements, double domes were not applied during the early Mughal period, but the type of *squinch* and pointed arch for covering big spaces arch type four - *Panj –O Haft Tond)* was completely influenced by Timurid architecture.
- The effect of Timurid architecture can be seen in the characteristics of *ivans,* for instance, forms, structure of ceiling, proportions, and the usage of Timurid geometrical systems (horizontally) in *qibla ivan*, and the relations of *ivans* with other spaces.
- Some features of domed chamber, such as the relation and composition with behind spaces and the usage of geometrical systems are similar to Timurid, however, the internal façade (load bearing systems and transitional system) was a blend of Mughal and Timurid features.
- The usage of geometrical systems was continued in the early phase of Mughal, and the proportion of the domed chamber and *qibla Ivan* are similar to Timurid architecture.

Results of Timurid influence in high level of Mughal period (second and third levels):

- Among formal elements, double-dome and *squinch* were more similar with Timurid architecture via the Safavid case study; the first time that double dome was utilized in Mughal mosques is in the high Mughal phase. The type of external shells and drums are similar to Timurid and Safavid architectures, the only difference between them is in the proportions of external shell in the late High Mughal case studies merging with Mughal architecture, and pointed arch being gradually combined with Mughal architecture from the first to late high Mughal case studies(refer to Figure 8.2).
- Between functional elements, the domed chamber is identical in manner to Timurid styles via Safavid in these features: the form, composition with behind spaces, and transitional systems. Also, some features of *ivans* are similar to the Timurid style via Safavid (structure of ceiling, number of *ivans*, relation of *qibla ivans* with behind spaces, proportions of *gibla ivans).* Despite the fact that both these elements are combined Safavid and Mughal architectures, it is less than similar to Timurid architecture compared to the early Mughal period(refer to Figure8.2).
- Two Timurid geometrical systems (one and four) were used more in high Mughal mosques rather than others, additionally; the domed chamber of high Mughal mosques was more ubiquitous in these systems compared to the *ivan* (see Figure 8.3).

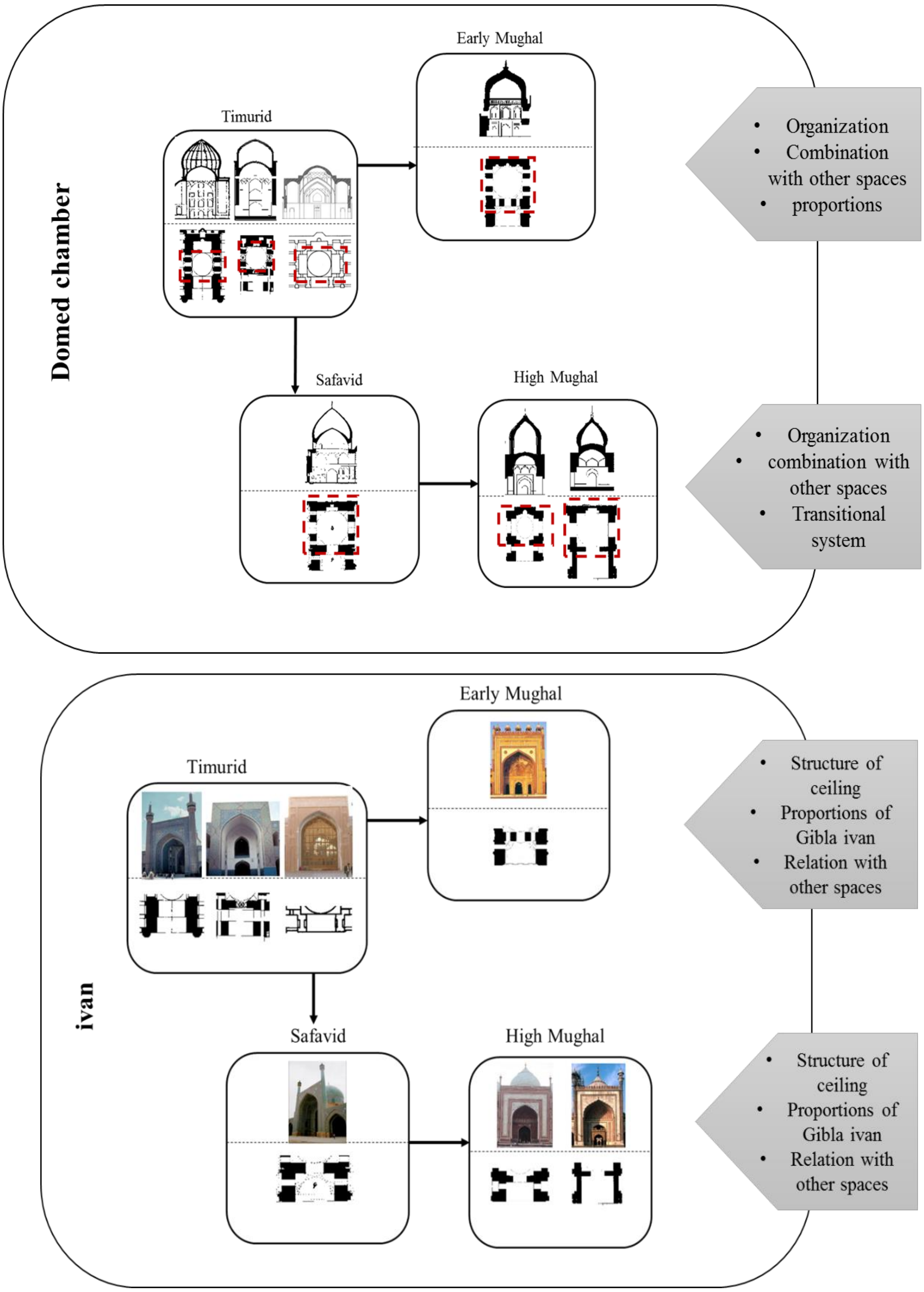


Figure 8.2: Over view of Timurid architectural influence in Mughal mosque (Author-2013)

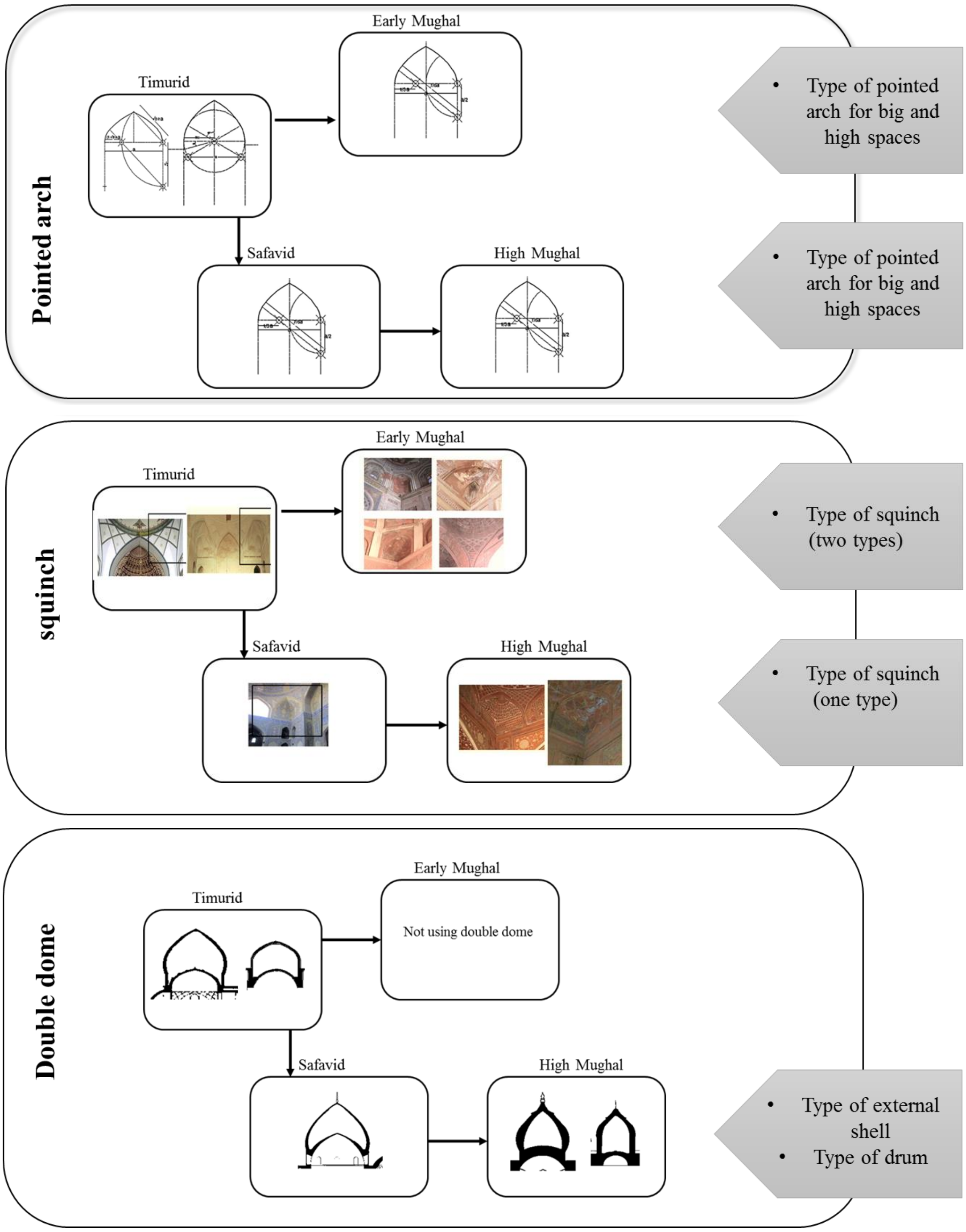


Figure 8.2: Over view of Timurid architectural influence in Mughal mosque (Author-2013)

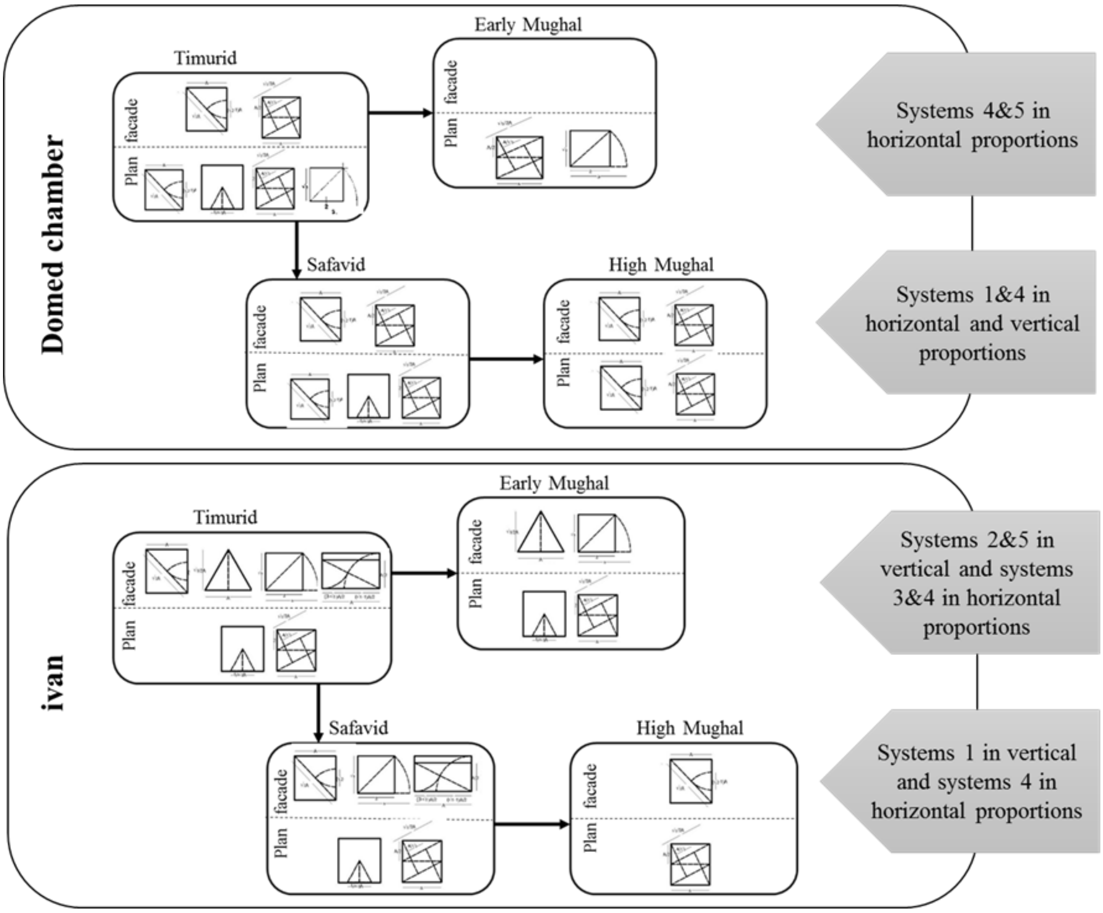


Figure 8.3: Overview of Timurid geometrical influence in Mughal mosque (Author-2013)

Objective 4: To define the evolution and alteration of Timurid architectural elements influencing Mughal mosques of India based on two periodical Mughal phases (early and high) and contributing factors.

- Among the five Timurid architectural elements, formal elements, including pointed arch, *squinch*, and domed chamber could be used in the near original face with less change.
- Timurid's *squinch* and pointed arch that was vastly in use in early Mughal mosque was continued in the high phase, but with a decrease in quantity and different types. Timurid Double domes was transferred to only high Mughal via Safavid influence. functional elements:

- Domed chamber and *Ivan* as functional elements were needed to match with Mughal mosques due to the different combinations between Timurid and Mughal mosques. Generally, in functional elements, façade elements, and proportions of façade can match Timurid architecture in the form of foreign styles. Moreover, both functional elements in the early phase of the Mughal era have more levels of similarity with Timurid architecture compared to the high phase.
- Between the proportions of *ivans* and domed chamber, *ivans* of Mughal architecture are more of a match with Timurid architecture, especially the *qibla ivan.* On top of that, in functional elements of Mughal mosques, vertical proportions are more of a match compared to the horizontal proportions in terms of Timurid architecture.
- The usage of Timurid geometrical systems decreased in the high phase of Mughal compared to the early phase for *ivans,* and more similarity can be seen in the *qibla ivan*, especially in horizontal proportions. On top of that, geometrical systems were applied more in plans rather than façade in functional elements, particularly for domed chambers. Geometrical system four is the most useful pattern in all Mughal case studies.

8.2. Contribution of knowledge

The research was concluded with primary and secondary findings that contribute to the body of knowledge. Generally, formal elements (both structural and ornamental), including pointed arch, *squinch*, and double domes could be used near the original face with less changes in both early and high Mughal phases. while the domed chamber and *ivan*, acting as functional elements, were needed to match Mughal mosques, due to the difference between Timurid and Mughal mosques (such as sizes and general form). Moreover, both functional elements in the early phase of the Mughal era have more levels of similarity with Timurid architecture compared to the high phase. The primary contribution of this research is as follows:

8.2.1. Pointed arch

Early and high phases of Mughal mosques utilized arch type 3-1(Panj –O Haft Tond) to cover all big spaces following Timurid architecture. This arch type was correspondingly used and developed in Timurid architecture. Despite the fact that cusped arch being a typical Mughal arch type and is visible in the Delhi Jami Mosque, two Timurid pointed arch (3-1 (Panj –O Haft Tond) and arch type 3-2 (Panj –O Haft Kond)) were used in certain spaces (see Figure 8.4).

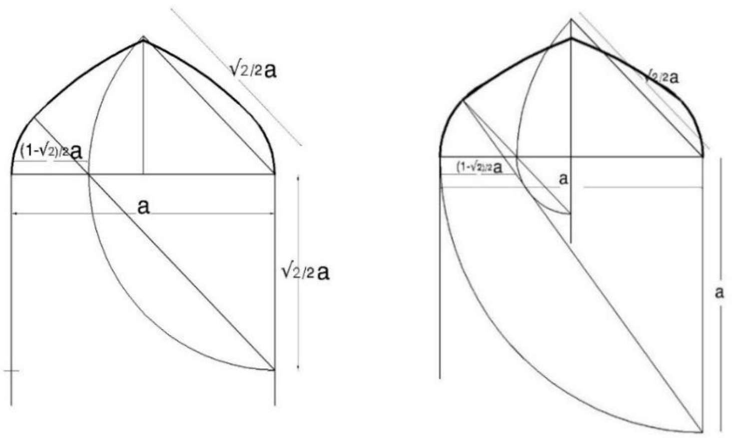


Figure 8.4: Arch type 4(Panj-O Haft Tond) left, Arch type 5(Panj-O Haft Kond) right(Pirnia, 1991)

8.2.2. Squinch

In Timurid architecture, different types of *squinch* can be found. This was continued in the early phase of Mughal mosques via the usage of groined vaults and a beam across the corner with revetment of arch-net (refer to Figure8.5). The famous Timurid *squinch* (groined vaults) were also used in Safavid architecture, and then were applied to the high Mughal phases.

Figure 8.5: Groined vaults (right), a beam across the corner with revetment of arch-net (left) (Author-2012)

8.2.3. Double dome

The influence of this Timurid element is not visible during the early Mughal period, as it was transferred via Safavid architecture during the high Mughal phase, and is obvious in both high Mughal case studies. Types of external shell and drum of both high Mughal case studies are similar to Timurid and Safavid features of double-dome. The proportion of external shell in Taj Mahal bears higher levels of resemblances to Timurid domes than to the Delhi Jami Mosque.

8.2.4. Ivan

Among Mughal case studies, only the Delhi Jami Mosque (belonging to the late Mughal period) followed the four *Ivan* mosque, with Timurid courtyards being common. Forms were the only similar Timurid patterns that were used in all of the Mughal case studies.

High similarities with Timurid features for early Mughal period is present in these features:

- Geometrical system in the plan of (west) in *gibla ivan*
- Proportions of *gibla ivans*
- Relation of *ivans* (south & east) with behind spaces.

These similar features were common in the early Mughal and Taj Mahal mosque as the first high Mughal case studies, but the Delhi Jami Mosque were free from Timurid and Safavid influence in the following features

- Relation of all *ivans* with behind spaces.
- Placement to behind spaces

Façade elements and proportions of qibla ivans

Geometrical systems

Among the Timurid geometrical systems, the plans are more of a match compared to the façade, with most of these similar systems being used in the west (*gibla) ivans* compared to others. Geometrical systems four and then one, with a square base, are the most useful in Mughal *ivans (*refer to Figure 8.6)

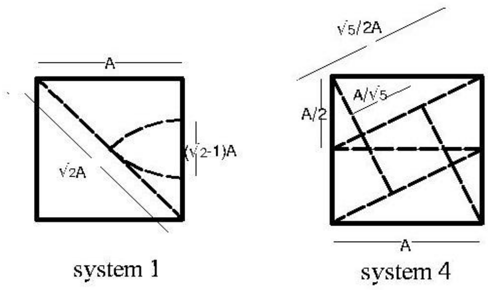


Figure 8.6: Timurid geometrical systems that used in *Ivans* of Mughal mosques (Golombek et al.,

Proportions and façade's elements

Generally, the only proportions of west *Ivan* or *gibla Ivan* matches the Timurid *ivan* model in both early and high Mughal period; the main reason for this similarity is the combination of west *ivan* with the domed chamber, like Timurid and Safavid. Despite the fact that the elements of the façade in the west *Ivan* are a mixture of more Timurid than

Mughal architecture. Other *ivans* were merged with big gateways, resulting in diverse blends.

8.2.5. Domed chamber

In both early and high Mughal period**,** high and medium similarities with Timurid architecture are realized in:

- Form
- Compositional pattern of negative and positive arches (positive for *mihrab* and negative for all opening to other spaces)
- Combination of domed chamber with *ivan* and *mihrab*
- Geometrical system in plan

Other features of Timurid architecture that can only be matched in the early Mughal period, such as:

- Windows
- Horizontal proportions
- Load bearing system
- Relation domed chamber with naves and *qibla ivan*

In contrast to both Fatehpur Sikri and Taj Mahal mosques, in the Delhi Jami Mosque, as one of the symbol of apex Mughal mosque; not one of these factors matches Timurid architectures.

- Transitional system
- Vertical proportions

Proportions &geometrical system

The Ratio of length-to-width in combination with the domed chamber, *ivan*, and *mihrab* in Fatehpur Sikri and Taj Mahal mosques was a complete match with Timurid mosques, and the ratio of length-to-width and height for domed-chamber in Fatehpur Sikri and Taj Mahal mosques matches Timurid architecture.

Timurid horizontal proportions can only be matched with the early Mughal, while the vertical proportion can also be matched with Fatehpur Sikri and Taj Mahal mosques. The proportions of the Delhi Jami Mosque, both vertically and horizontally, are free from the influences of Timurid architecture.

The proportion of the *mihrab* and the geometrical system in the façade did not influence the early and high Mughal periods.

It can be seen in two contrasting manner in the dome chamber of Mughal mosques; the similarity of geometrical systems only in the plan (and not in the façade), and the similarity of vertical proportions more than the horizontal ones. The Timurid geometrical system being greatly utilized in Mughal mosques was system four.

8.2.6. Proportion and geometrical systems in functional elements

- Generally, in functional elements of Mughal mosques, vertical proportions are more of a match than horizontal proportions to Timurid architecture.
- Between the proportions of *ivans* and domed chamber, *ivans* of Mughal architecture are more of a match to Timurid architecture.
- In the Fatehpur Sikri and Taj Mahal mosques, the proportion between the combinations of three spaces (*mihrab*, domed chamber, *gibla Ivan*) is similar to Timurid architecture.
- The contrast of compatibility between geometrical systems and proportions (vertically and horizontally) is only seen in domed chambers, while *ivans* are analogous in the context of horizontal and vertical proportions with geometrical systems in both plans and façades.

- Geometrical systems were being used more in plan rather than façade in functional elements, particularly in the case of domed chambers. Geometrical system four is the most useful pattern in all Mughal case studies. This pattern is based on the relation of two squares (see Figure 8.7)

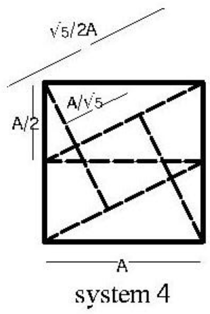


Figure 8.7: Most useful Timurid Geometrical system in Mughal mosques (Golombek et al., 1988)

8.3. Limitation and future works

There are some limitations in the process of doing this research that can be listed as follows:

It is not claimed that this research (Timurid architectural influence in Mughal mosques), covered all Timurid and Mughal samples. Due to shortage of time, the case studies only were selected in Iran and India, and other regions such as Central Asia and Pakistan were escaped.

Moreover, the routes of Timurid architectural transition comprised three propositions. In this research only focused in the second and third ones (direct Timurid influence and indirect Timuird influence via Safavid period), and the indirect Timurid influence via Indian styles (that were contemporary with Timurid) was omitted.

Among the all Timurid architectural elements that mentioned in chapter four, only five of them were studied in case studies, and others such as intersecting arch, mosaic faience, and arch and panel systems were omitted.

In addition, various aspects of architectural transition from one style to other one can be assumed such as architectural aesthetical principles, architectural concepts, and architectural elements. This research only covered architectural elements.

To sum up, some significant proposals for future works can be underlined as follow:

- To investigate the Timurid architectural elements in Central Asia region composing Afghanistan, Uzbekistan and Turkmenistan.
- To examine the Timurid architectural elements in Pakistan as one of main region of Mughal period that three main Mughal mosques (Tata mosque, Badeshahi mosque, Wazir khan mosque) are located in this country.
- To examine the other Timurid architectural elements (intersecting arch, mosaic faience, arch and panel systems) in Mughal mosques.
- To verify and examine first propositions of Timurid influence in Mughal mosque (indirect influence via Delhi sultanate that its late period was concurrent with Timurid period).
- To investigate and examine Timurid aesthetical principles and Timurid architectural concepts in the Mughal mosques.
- To investigate and examine Timurid architectural elements in other type of Mughal buildings and find similarity of Timurid architectural elements between Mughal mosques and other type of Mughal buildings.

- To investigate the Timurid architectural elements in buildings of British colonial period via Mughal style in the east south Asian countries such as Malaysia.[4]

[4] After domination of Britannia in India, British architects have tried to use the local art for conformity with national culture, they established the eclectic style that created from combination of Mughal and Gothic styles and it was called " Indo –Gothic , Mughal –Gothic , Neo Gothic " . this movement have increased and developed in the other colonial countries that one of them is Malaysia (Chen, 1998).

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LIST OF PUBLICATIONS AND PAPERS PRESENTED

Table I-List of Publications

No	Title	journal	Index	ISSN	Published
1	**ARCHITECURAL TRANSFER BETWEEN TWO NON-CUNCURRENT STYLES: INVESTIGATION THE ROUTS OF TIMURID ARCHITECTURAL INFLUENCE (1370-1524AD) IN MUGHAL BUILDINGS (1526-1707 AD)**	**Australian journal of basic and applied science** (category A of acceptable journal of alam bina)	**Scopus**	1991-8178	**April 2013**
2	**MUGHAL OR MOORISH ARCHITECTURE: THE ORIGINS OF MALAYSIAN MOSQUES DURING COLONIAL PERIODS (1800-1930)**	**Pertanika journal of social science and humanities (JSSH)** (category A of acceptable journal of alam bina)	**Scopus**	2231-8542	**September 2015**

Table II -List of Conference Papers

No	Title	Conference	Place	Year
1	**Mughal Or Moorish architecture : Investigate The Origins Of Malaysian Mosques During Colonial Periods(Case Study: Jame Mosque)**	2^{nd}. International Conference on Arts, Social Sciences & Technology	Penang, Malaysia	march 2012
2	**Process Evolution Of Typologies In Persian Mosque Architecture** indexed in ISI Proceedings/CPCI (Thomson Reuters) and Scopus	World Conference on Islamic Thought 2012: Contemporary Challenges And Realities	Ipoh, Malaysia	September ,2012
3	**Contemporary Tendencies to Apply The Traditional Architecture According To Historical Periods**	*6th ASEAN Post Graduate Seminar in Built Environment 2012*	Kuala lumpur, Malaysia	December 2013
4	**The Routs Of Timurid Architectural Influence (1370-1524) In Mughal Buildings (1526-1709)**	6th International Conference and Workshop On The Built Environment In Developing Countries	Adelaide , Australia	December 2013

APPENDIX

Appendix A: List of all mosques (Timurid –Mughal - Safavid)

Table A-1: Timeline of Timurid mosques (Author-2012)

Name	place	Date of construction	Period
Great Mosque of Herat	Herat, Afghanistan	1200, 1498	Ghurid, Timurid(Golombek et al,1998)
Shah zendeh mosques	Samarkand, Uzbekistan	1350-mid 15th c.	Timurid(Golombek et al,1998)
Bibi Khanum Mosque	Samarkand, Uzbekistan	1398-1405	Timurid(Golombek et al,1998)
Gawhar Shad Mosque	Mashhad, Iran	1405-18	Timurid(Golombek et al,1998) (Golombek et al,1998)
Friday Mosque of Torbat-i-Jam	Torbat-i Jam, Iran	1442-5	Timurid(Golombek et al,1998)
Mir Chaqmaq Mosque	Yazd, Iran	1437	Timurid(Golombek et al,1998)
Ghiyathiyya mosque	Khargird, Iran	1438-1444	Timurid(Golombek et al,1998)
Masjid-i Shah of Mashad	Mashad, Iran	1451	Timurid(Golombek et al,1998)
Masjid-i Mawlana	Taybad, Iran	1444-5	Timurid (Pope.1965)
Darb-i Imam mosque	Isfahan, Iran	1453, 1601,1670-71	Timurid ,Safavid(Pirnia,2001)
Masjid-i Kabud	Tabriz, Iran	1465	Timurid (Pirnia,2001)
Friday Mosque of varzaneh	Varzaneh,iran	1466-1721	Timurid, Safavid(Pope.1965)
Masjid-i Maidan	Kashan, Iran	1468	Timurid, Safavid(Pope.1965)
Friday Mosque of Ziyaratgah	Ziyaratgah, Afghanistan	1482-1485	Timurid(Golombek et al,1998)
Shah Vali Mosque	Taft, Iran	1468-1484	Timurid(Golombek et al,1998)
Chihil Sutun Mosque	Ziyaratgah, Afghanistan	circa 1485	Timurid(Golombek et al,1998)
Kalyan Mosque	Bukhara, Uzbekistan	early 14th C., 1514	Shaybanid, Timurid
Friday Mosque of Neyshabur	Neyshabur ,Iran	1521, 1643	Timurid, Safavid(Pirnia,2001)
Friday Mosque of Abrand	Abrand Abad,Iran	16^{th}	Timurid(Pirnia,2001)
Friday Mosque of Hendovalan	Birjand,Iran	16^{th} ,18^{th}	Timurid , Safavid(Pirnia,2001)
Ano mosque	Eshghabad Turkmenistan	1447-1457	Timurid(Pirnia,2001)

Table A-2: Timeline of Safavid mosques (Author-2012)

No	Name of king	Name	place	Date of construction	Period
1	Shah Ismail I	**Ali Mosque**	Isfahan, Iran	1522	Safavid ,Seljuk(Pirnia,2001)
2	Shah Tahmasb	**Janatsar mosque**	Ardebil,, Iran	1537	Safavid(Pope.1965)
3	Shah Abbas I	**Ganj-i Ali Khan mosque**	Kerman ,Iran	1598	Safavid(Pirnia,2001)
4	Shah Abbas I	**No Mosque**	Shiraz, Iran	1600	Safavid (Pope.1965)
5	Shah Abbas I	**Shah Mosque**	Isfahan, Iran	1611-1638	Safavid(Pirnia,2001)
6	Shah Abbas I	**Shaykh Lutfallah Mosque**	Isfahan, Iran	1617	Safavid(Pirnia,2001)
7	Shah Abbas I	**Khan Mosque**	Shiraz ,Iran	1627	Safavid(Pope.1965)
8	Shah Safi	**Agha nor mosque**	Isfahan, Iran	1637	Safavid(Pope.1965)
9	Shah Abbas II	**Hakim Mosque**	Isfahan, Iran	1656-62	Safavid(Pirnia,2001)
10	Shah Sultan Huseyn	**Aligholiagha mosque**	Isfahan, Iran	1709	Safavid(Pirnia,2001)

Table A-3: Timeline of Mughal mosques (Author-2012)

N	Name of king	Name	place	Date of construction	Period
1	Babur	**Sambhal Mosque**	Moradabad-Uttar Pradesh	1526	Mughal (Koch ,1991)
2	Babur	**Kabuli Bagh Mosque**	Panipat - Haryana	1528-29	Mughal(Koch ,1991)
3	Babur	**Ayodha Mosque**	Faizabad- Uttar Pradesh	1528-29	Mughal(Koch ,1991)
4	Humayon	**Kachpura Mosque**	Agra- Uttar Pradesh	1530-31	Mughal(Pereira, 1994)
5	Akbar	**Afsarwala Mosque**	Delhi-	1560	Mughal(Fergussen, 1979)
6	Akbar	**Khayr Al-Manazil Mosque**	Delhi	1561	Mughal(Pereira, 1994)
7	Akbar	**Fatehpur Sikri Friday Mosque**	Fatehpur Sikri	1568-78	Mughal(Pereira, 1994)
8	Akbar	**Dargah Mosque**	Ajmer-Rajasthan	1570	Mughal(Fergussen, 1979)
9	Jahangir	**Pattar Mosque**	Srinagar-Kashmir	1602	Mughal(Koch ,1991)
10	Jahangir	**Beygum Shahi Mosque**	Lahore-Pakistan	1611	Mughal Koch ,1991)
11	Shah jahan	**Mina Mosque**	Agra- Uttar Pradesh	1630	Mughal(Fergussen, 1979)
12	Shah jahan	**Moti Mosque**	Lahore- Pakistan	1630	Mughal(Koch ,1991)
13	Shah jahan	**Wazir Khan Mosque**	Lahore- Pakistan	1634-35	Mughal(Koch ,1991)
14	Shah jahan	**Shah Jahan Mosque**	Ajmer - Rajasthan	1636	Mughal(Pereira, 1994)
15	Shah jahan	**Negina Mosque**	Agra- Uttar Pradesh	1637	Mughal(Pereira, 1994)
16	Shah jahan	**Taj Mahal Mosque**	Agra- Uttar Pradesh	1640-50	Mughal(Pereira, 1994)
17	Shah jahan	**Tatta Mosque**	Tatta- Pakistan	1644-1657	Mughal(Fergussen, 1979)
18	Shah jahan	**Moti Mosque**	Agra - Uttar Pradesh	1647-53	Mughal(Fergussen, 1979)
19	Shah jahan	**Agra Jame Mosque**	Agra- Uttar Pradesh	1648	Mughal(Koch ,1991)
20	Shah jahan	**Akbarabadi Mosque**	Delhi	1650	Mughal
21	Shah jahan	**Sirhindi Mosque**	Delhi	1650	Mughal(Fergussen, 1979)
22	Shah jahan	**Delhi Jame Mosque**	Delhi	1650-56	Mughal(Koch ,1991)
23	Aurangzib	**Badshahi Mosque**	Lahore- Pakistan	1637-74	Mughal(Koch ,1991)
24	Aurangzib	**Moti Mosque**	Delhi	1663	Mughal(Koch ,1991)
25	Aurangzib	**Ghazi-Al Din Khan Mosque**	Delhi	1710	Mughal

Appendix B: Study trip for data collection

Table B-1: List of Indian and Iranian architectural and historical organization for gathering documents (Author-2012)

No	city	Name
1	Mashahd	Astan Ghods Razavi foundation
2	Mashahd	cultural heritage, handcrafts, and tourism organization
3	Yazd	cultural heritage, handcrafts, and tourism organization
4	Isfahan	cultural heritage, handcrafts, and tourism organization
5	Delhi	Iran cultural house
6	Delhi	Indira Gandi national center for art
7	Delhi	Indian national trust for art and cultural heritage
8	Delhi	National archives of India
9	Delhi	School of planning and architecture
10	Delhi	Indian council for historical research

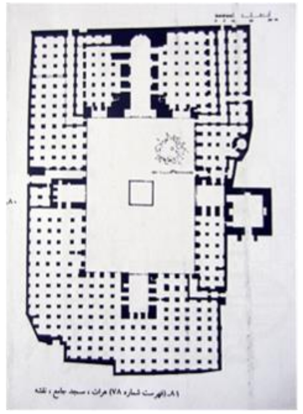
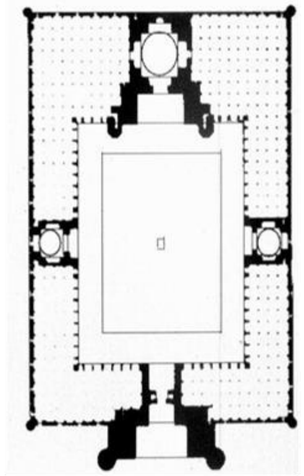
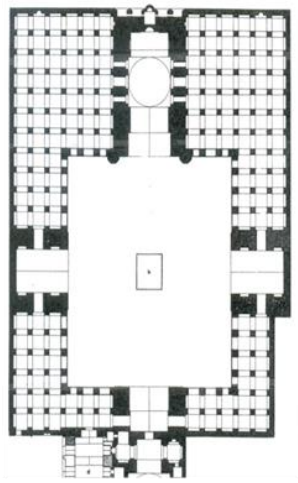
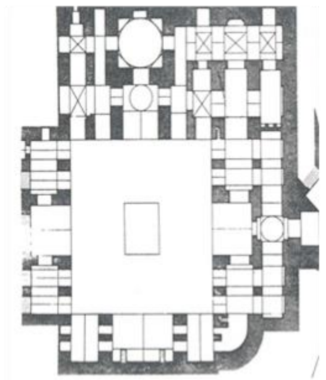
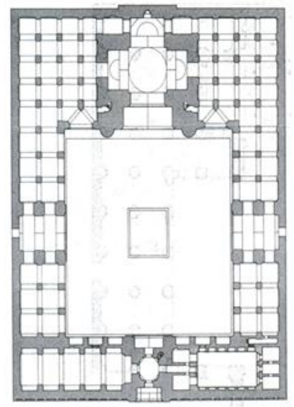
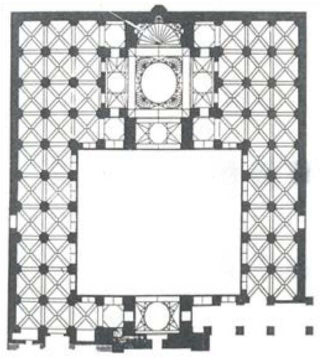
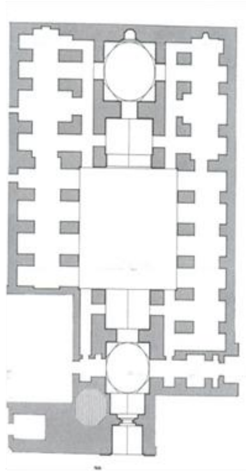
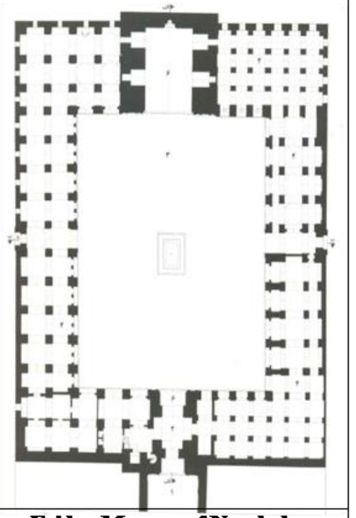
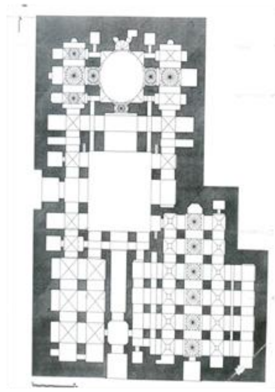
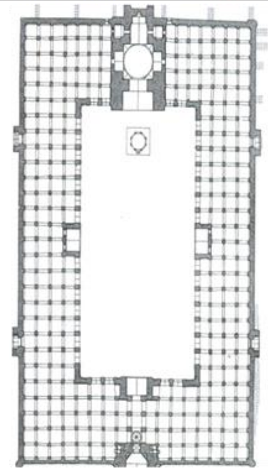
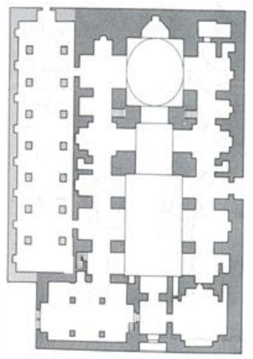
Table B-2: Sample of checklist (Author-2012)

Date of visit:
Name of mosque:
Name of period:
Year built

Type of mosque			
1	ivan	Elements of ivan screen	Shape
		Number of ivan :	
		relation	
		Material	
2	Domed chamber	Elements of load bearing system	Shape
		Elements of transitional system	
		Opening	
		relation	
		Material	
3	Double dome	Type	
		Type of external shell	
		Type of internal shell	
		Material	
4	*Squinch*	Type	
		Position	
		Material	
5	Pointed arch	Type	
		Position	

Appendix C: Typology of Timurid and Mughal mosques

Table C-1: Typologies of Timurid mosques (Author-2012)

four –*ivan* mosque						
Name	Great Mosque of Herat	Bibi Khanum Mosque	Gawhar Shad Mosque	Darb-i Imam mosque	Masjid-i Maidan	Friday Mosque of Ziyaratgah
mosque with two Iwans, court						
Name	Friday Mosque of Torbat-i-Jam	Friday Mosque of varzaneh	Friday Mosque of Neyshabur		Mir Chaqmaq Mosque	Kalyan Mosque
mosque with one *Iwan*, court						
Name	Friday Mosque of Abrand					

1. mosque with one or two *Iwans*, court
2. four –*ivan* mosque
3. *ivan* mosque without domes
4. The square many-bayed omnidomed mosque
5. Central domed chamber and omnidomed wings
6. *Narthex-and-Noas* or domed apsidal mosque
7. Mosque integrated to madrassa-tomb

Table C-1: Typologies of Timurid mosques (Author-2012)

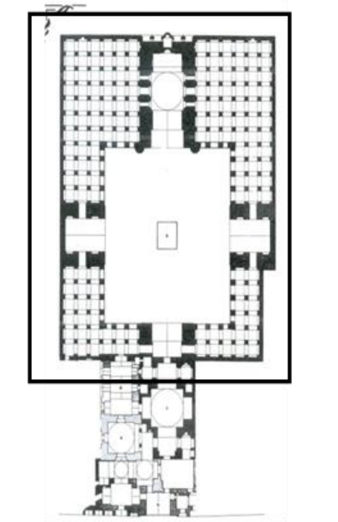
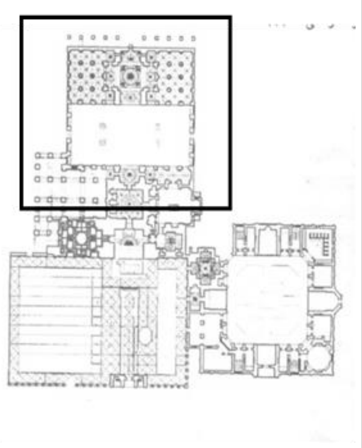
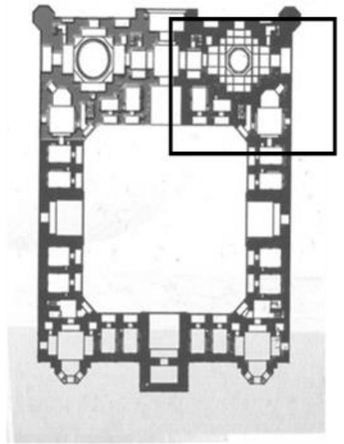
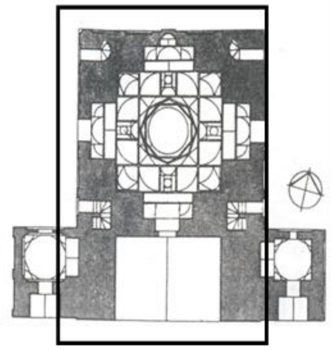
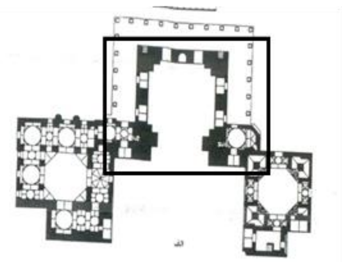
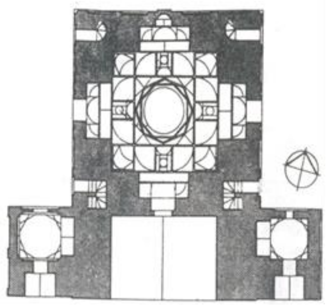
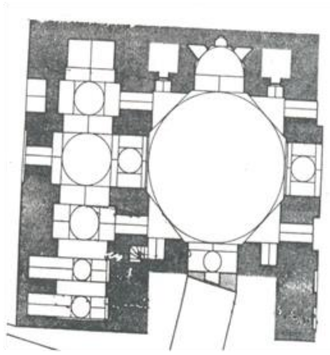
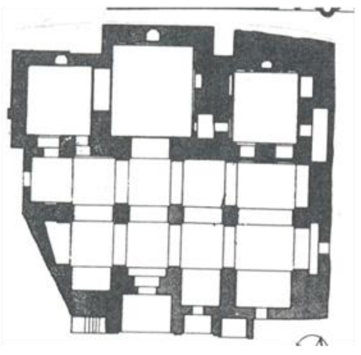
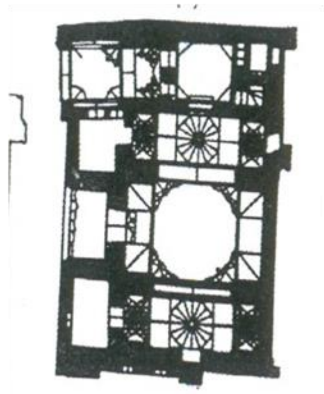
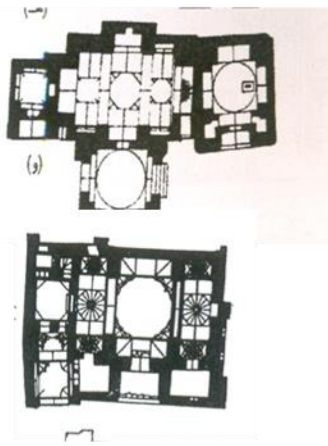
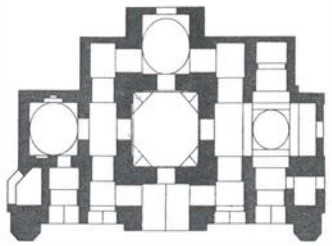
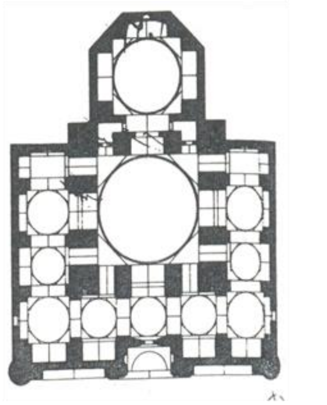
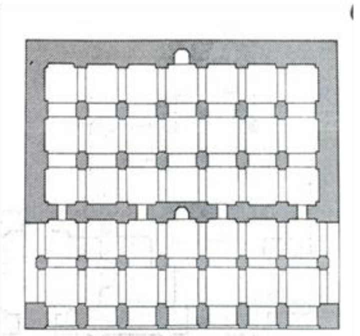
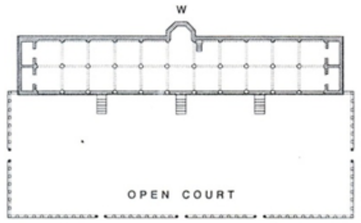
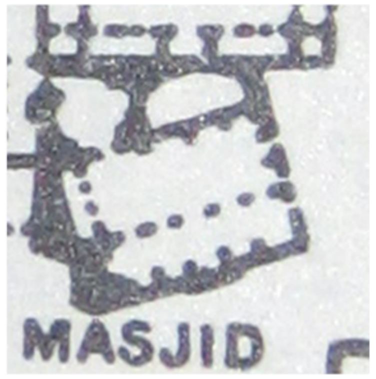
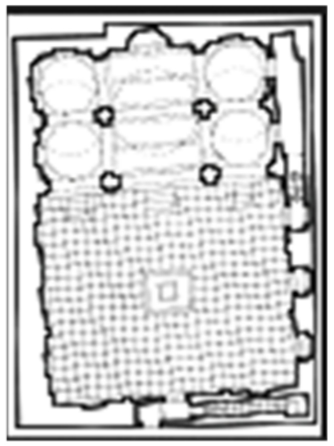
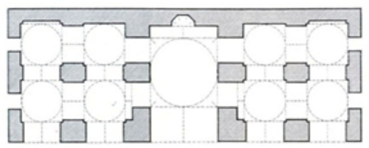
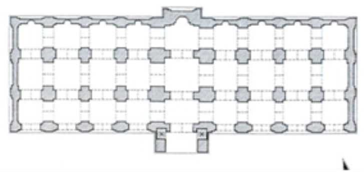
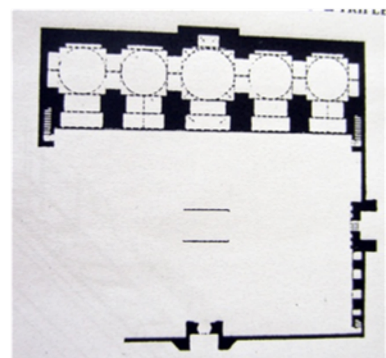
Mosque integrated to madrassa-tomb						
Name	Gawhar Shad Mosque	Friday Mosque of Torbat-i-Jam	Ghiyathiyya mosque	Masjid-i Mawlana	Darb-i Imam mosque	Ano mosque
mosque with one *Ivan*, court						
Name	Masjid-i Mawlana	Shah Vali Mosque	Friday Mosque of Hendovalan	Shah zendeh mosque		Shah zendeh mosques
Other type s of mosques						
Name	Masjid-i Shah of Mashad	Masjid-i Kabud	Chihil Sutun Mosque			

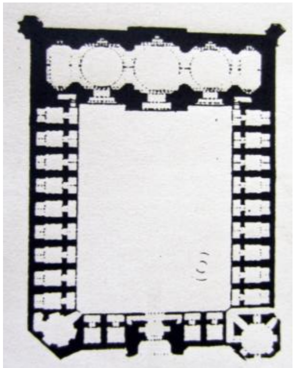
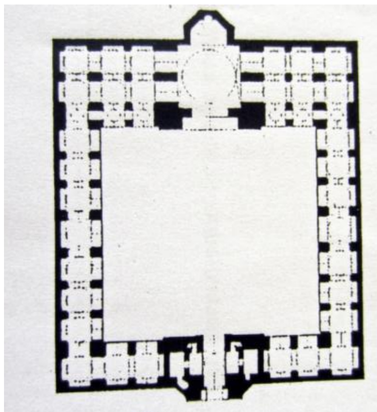
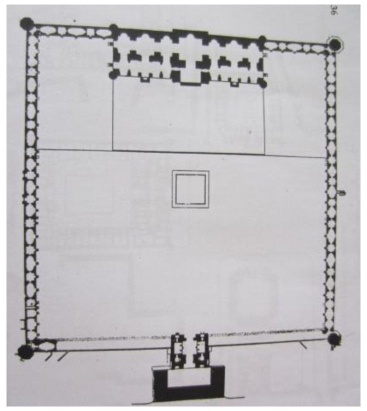
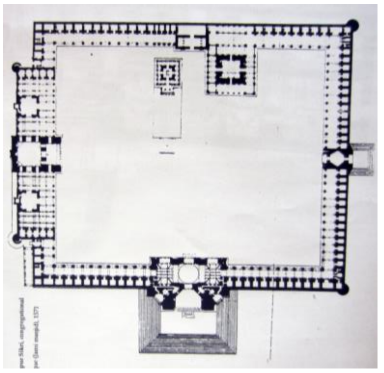
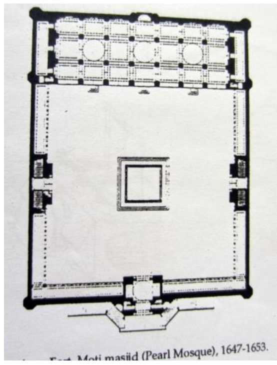
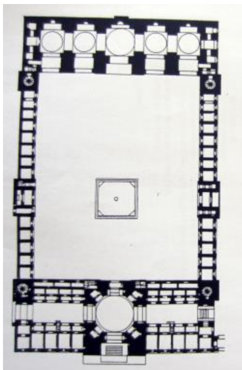
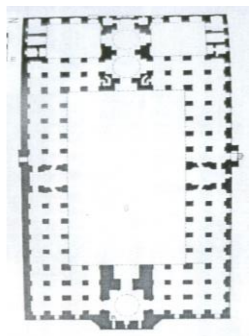
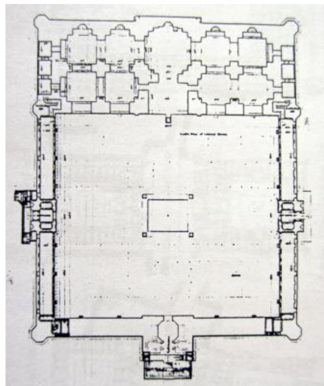
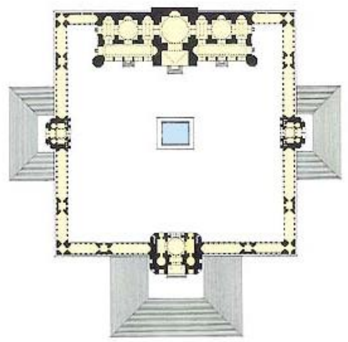
Table C-2: Typologies of Mughal mosques (Author-2012)

mosques no sanctuary *pishtaq* and no cloisters						
Name	**Mina Mosque**	**Shah Jahan Mosque**	**Negina Mosque**			
mosques no sanctuary *Pishtaq* but with cloister						
Name	**Lahore Moti Mosque**	**Delhi Moti Mosque**				**Taj Mahal Mosque**
mosques with sanctuary *Pishtaq* but with no cloister						
Name	**Ayodha Mosque**	**Kabuli Bagh Mosque**	**Afsarwala Mosque**	**Kachpura Mosque**	**Pattar Mosque**	**Beygum Shahi Mosque**

Typology of Mughal Mosque

- mosques no sanctuary pishtaq and no cloisters
- mosques no sanctuary *Pishtaq* but with cloister
- mosques with sanctuary *Pishtaq* but with no cloister
- mosques with both sanctuary *Pishtaq* and cloisters with *Ivans*

Table C-2: Typologies of Mughal mosques (Author-2012)

mosques with both sanctuary *Pishtaq* and cloisters with two *Ivans*				
Name	**Khayr Al-Manazil Mosque**	**Dargah Mosque**	**Badshahi Mosque**	
mosques with both sanctuary *Pishtaq* and cloisters with three *Ivans*				
Name	**Fatehpur Sikri Jame Mosque**	**Agra Moti Mosque**		
mosques with both sanctuary *Pishtaq* and cloisters with four *Ivans*				
Name	**Wazir Khan Mosque**	**Tatta Mosque**	**Agra Jame Mosque**	**Delhi Jame Mosque**

Appendix D: Geometrical analysis of functional elements of case studies

Table D-1: Geometrical analysis of south *ivan* (Timurid case studies) (Author-2013)

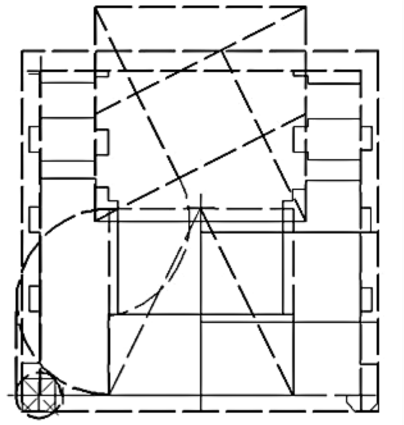
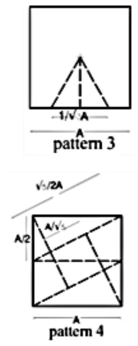
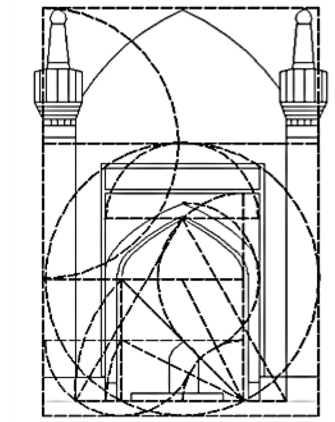
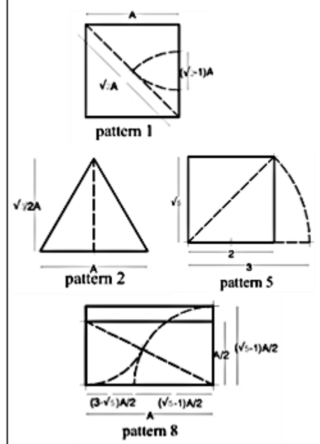
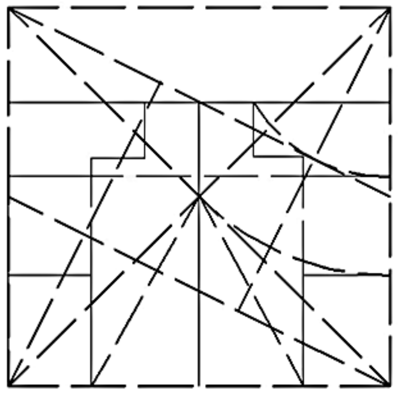
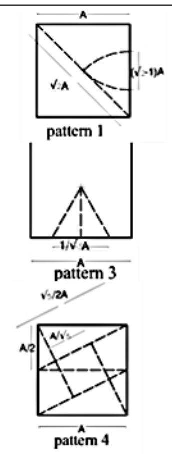
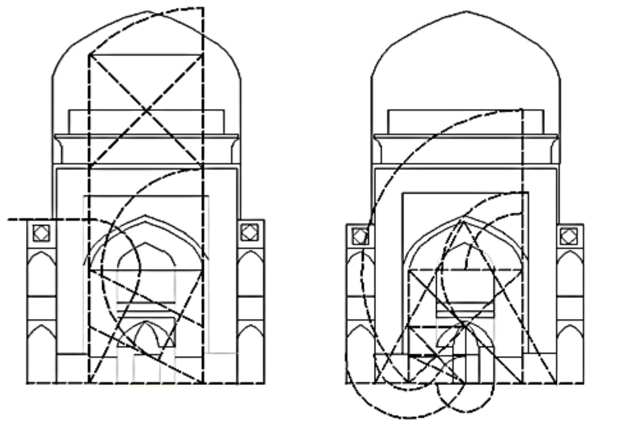
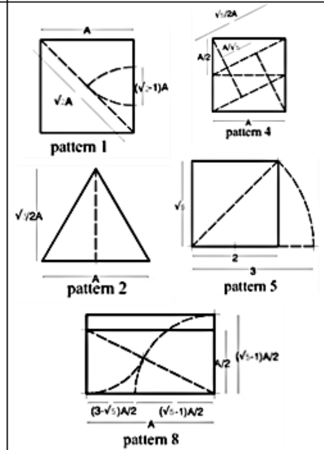
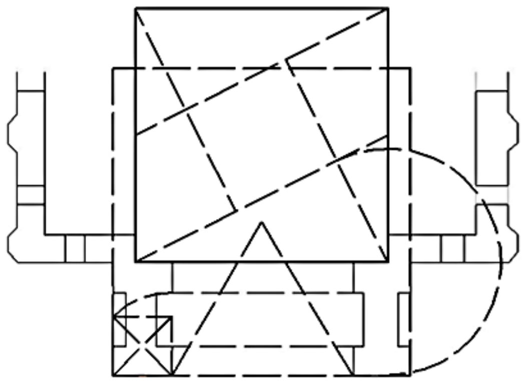
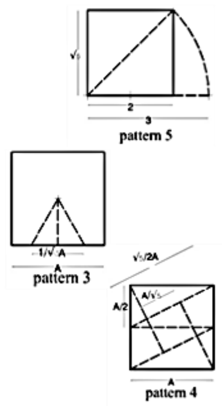
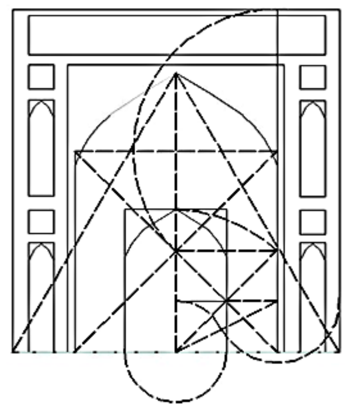
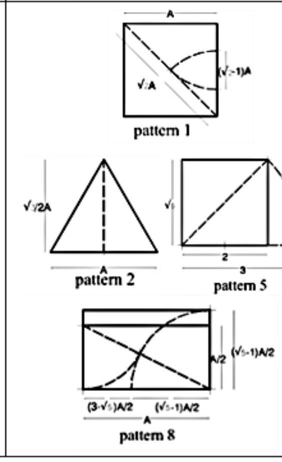
name of mosque	plan	Geometrical patterns	facade	Geometrical patterns
Gawhar Shad Mosque				
Mir Chaqmaq Mosque				
Mosque of Torbat-I-Jam				

Table D-2: Geometrical analysis of north, east and west *ivans* (Timurid case studies) (Author-2013)

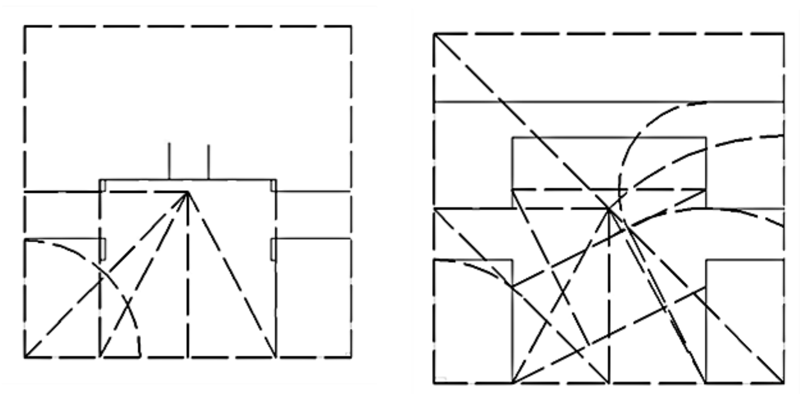
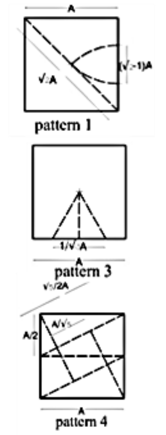
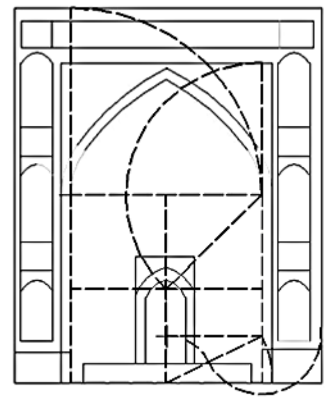
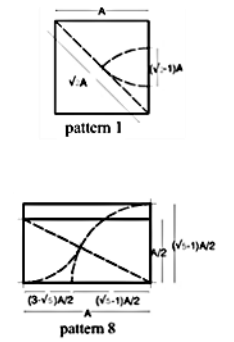
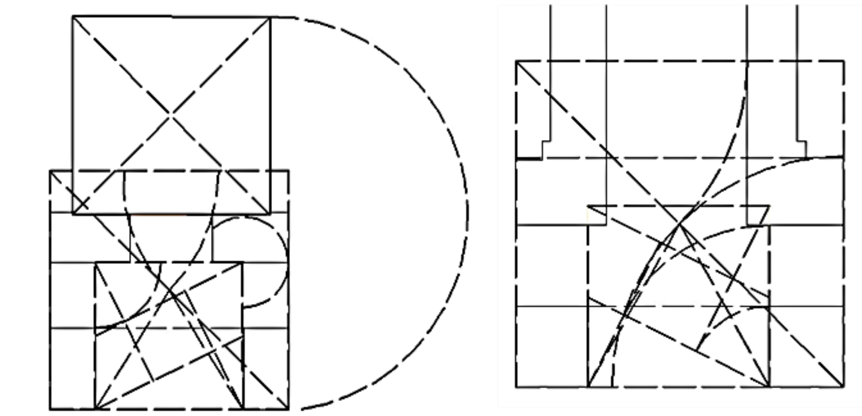
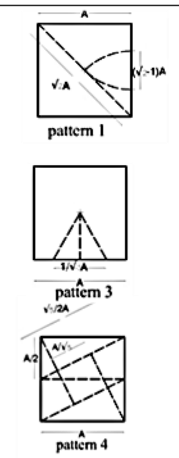
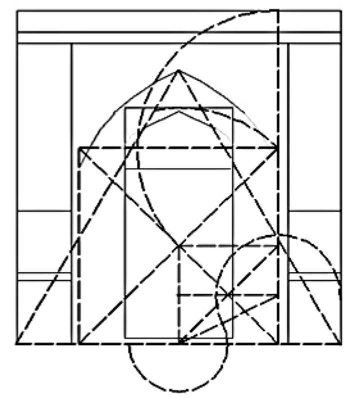
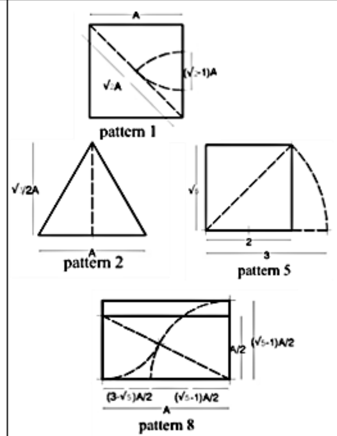
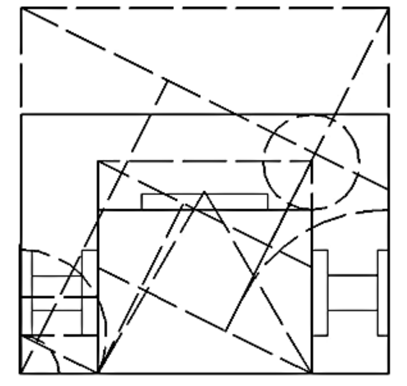
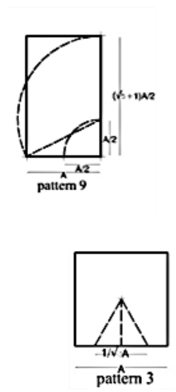
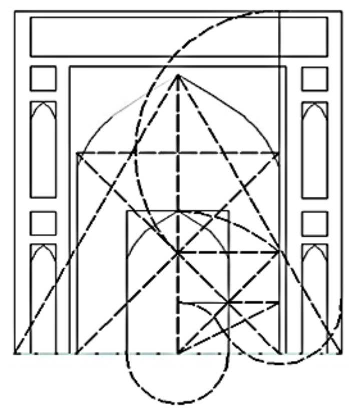
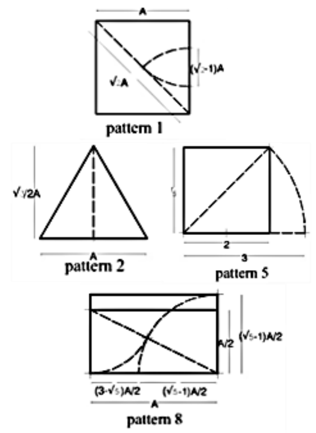
	plan	Geometrical patterns	facade	Geometrical patterns
Gawhar Shad Mosque				
Mir Chaqmaq Mosque				
Mosque of Torbat-i-Jam				

Table D-3: Geometrical analysis of domed chambers (Timurid case studies) (Author-2013)

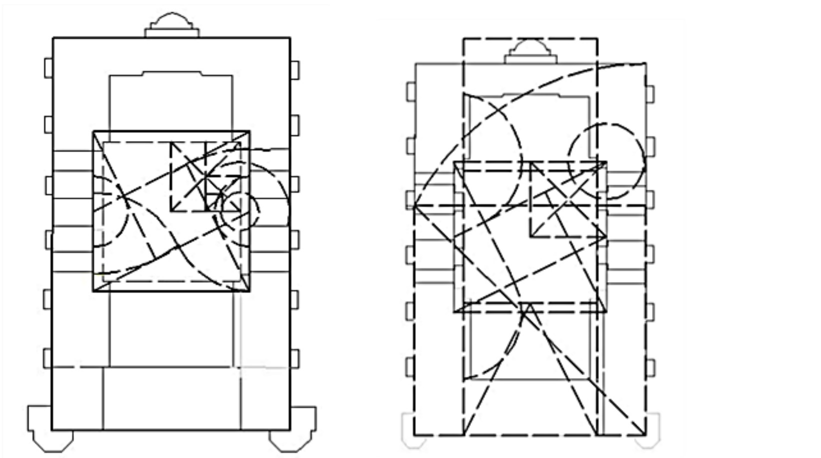
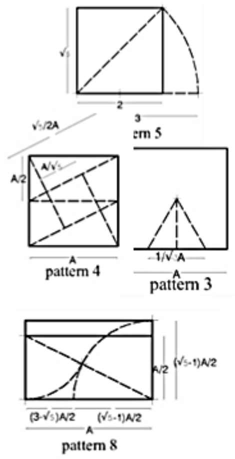
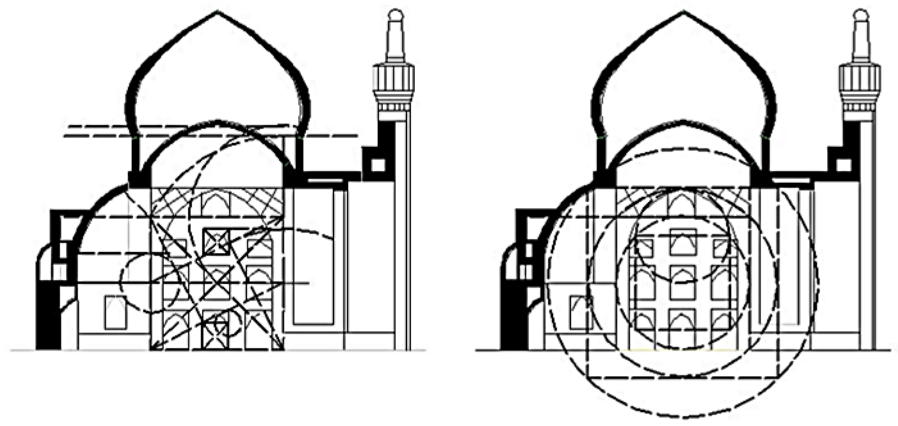
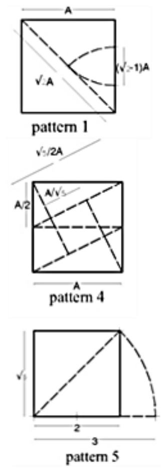
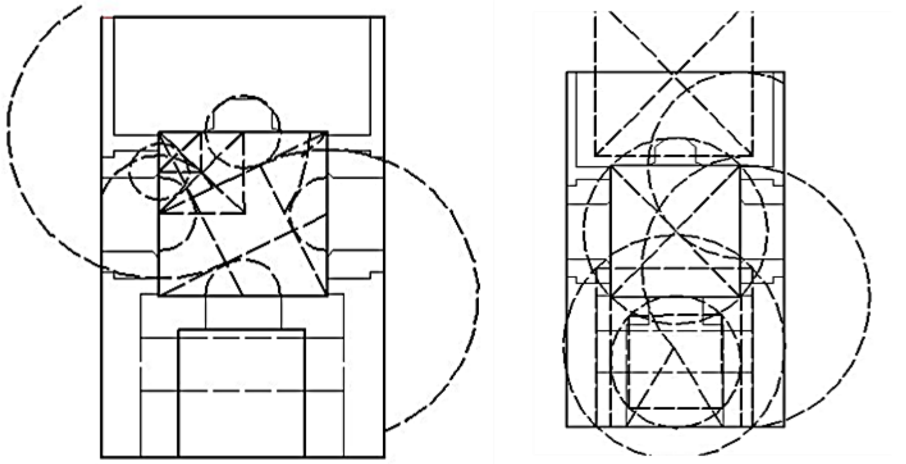
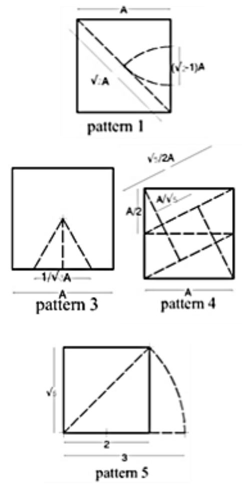
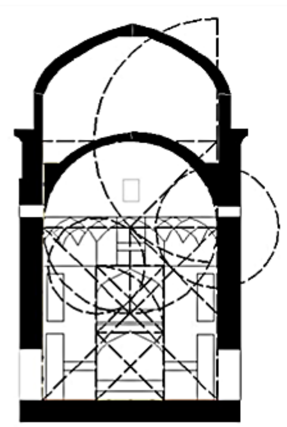
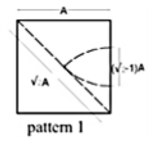
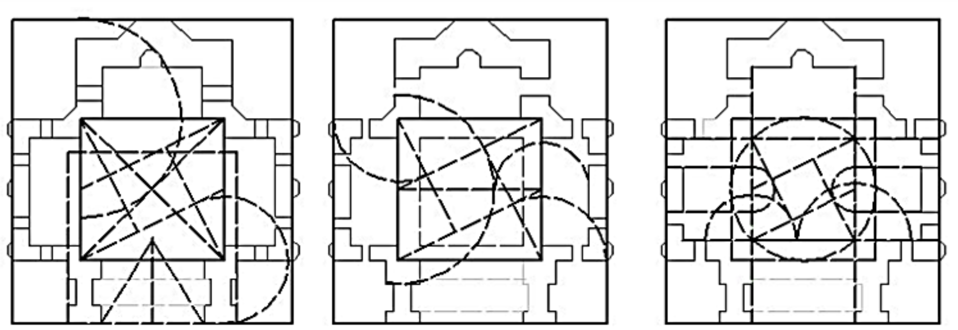
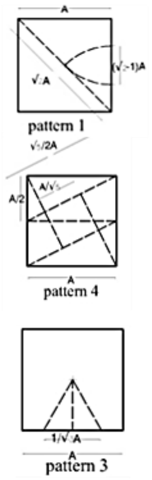
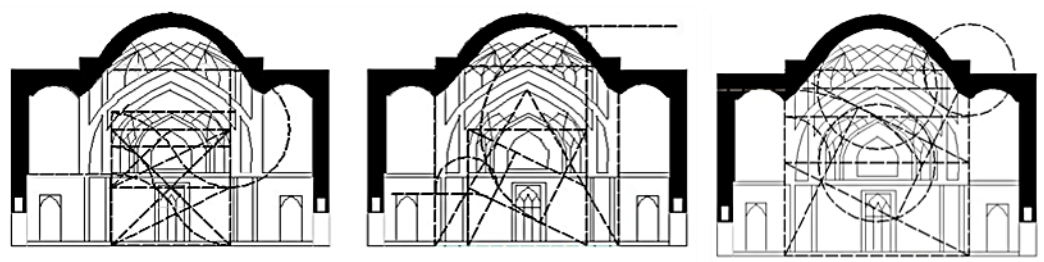
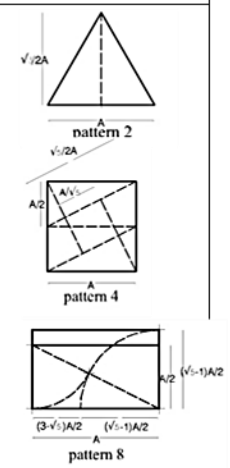
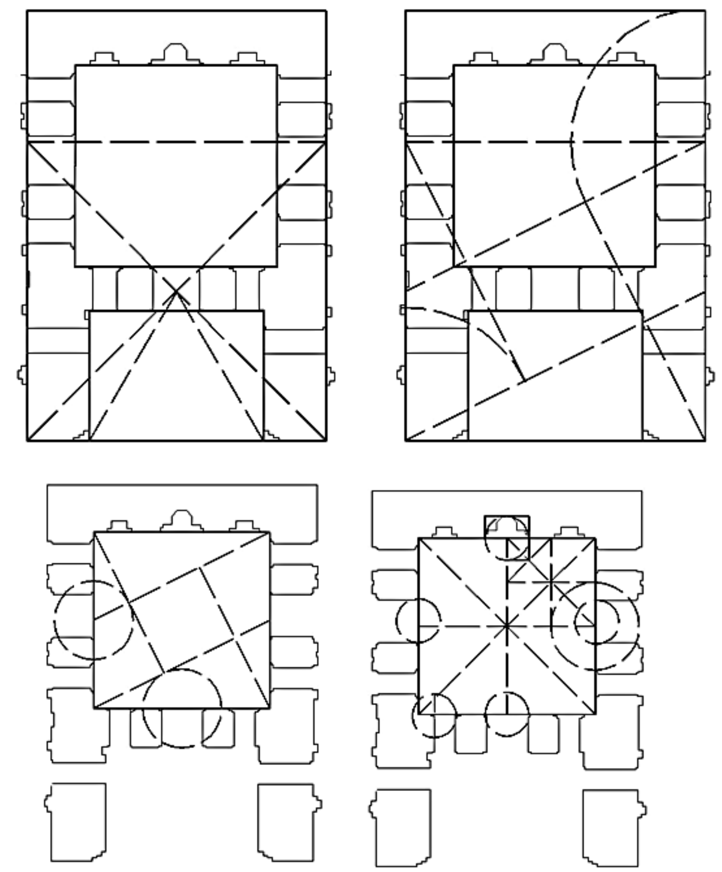
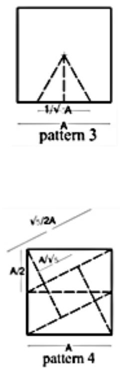
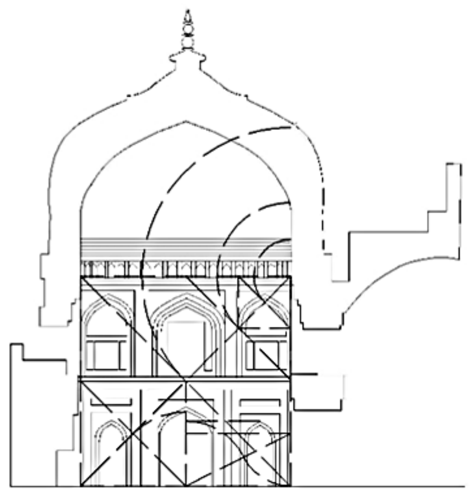
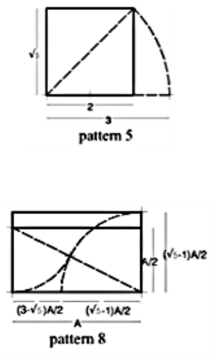
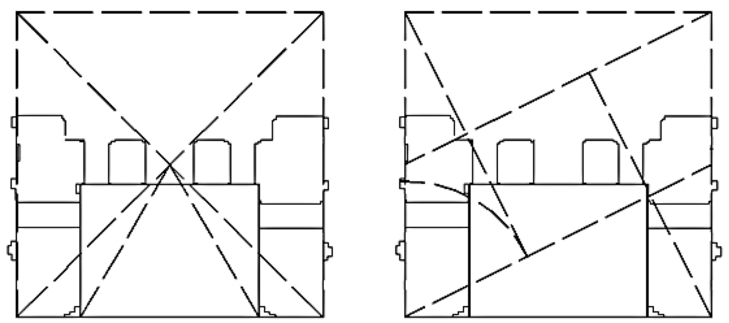
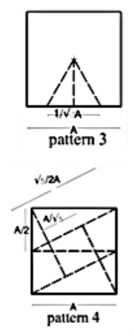
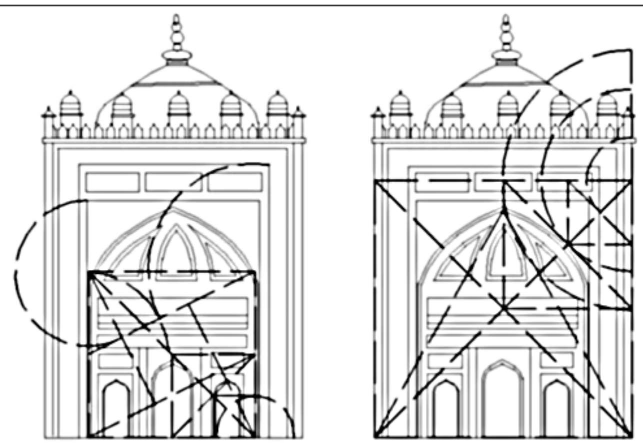
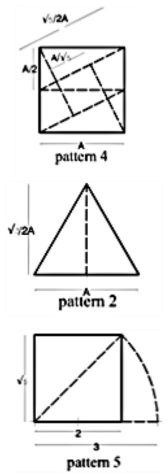
	plan	Geometrical patterns	facade	Geometrical patterns
Gawhar Shad Mosque				
Mir Chaqmaq Mosque				
Mosque of Torbat-I-Jam				

Table D-4: Geometrical analysis of Fatehpur Sikri Mosque (Early Mughal case studies)(Author-2013)

	plan	Geometrical patterns	facade	Geometrical pattern
Fatehpur sikri mosque domed chamber				
Fatehpur sikri mosque west Ivan				

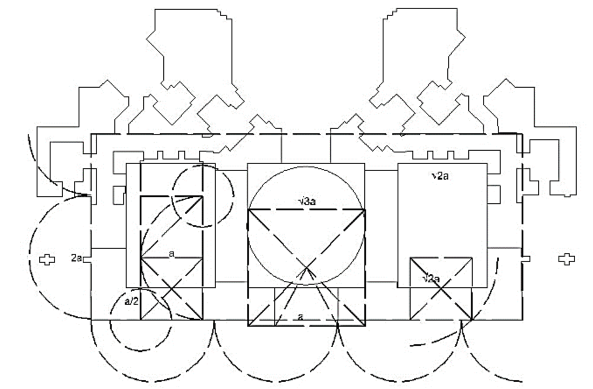
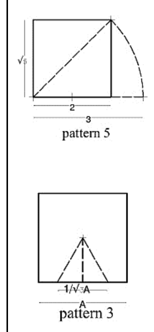
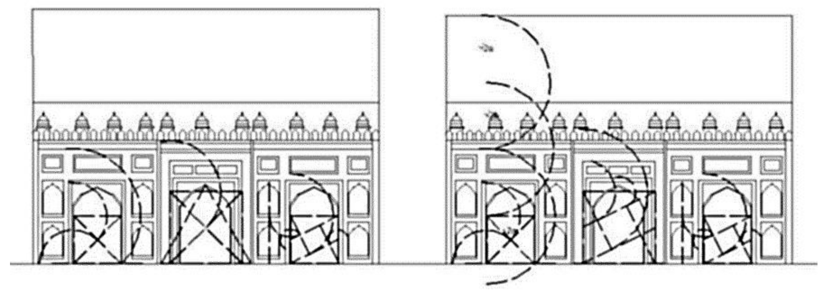
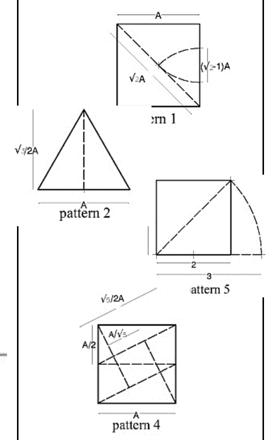
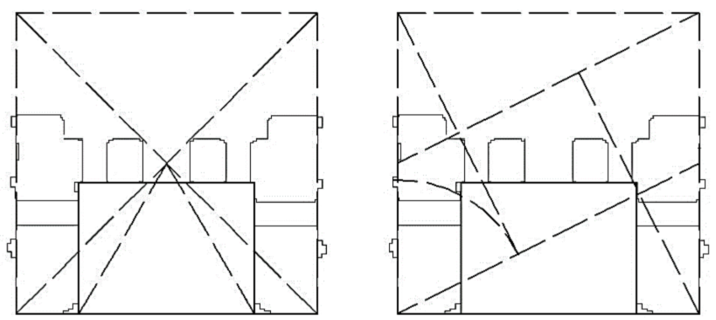
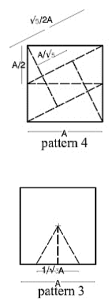
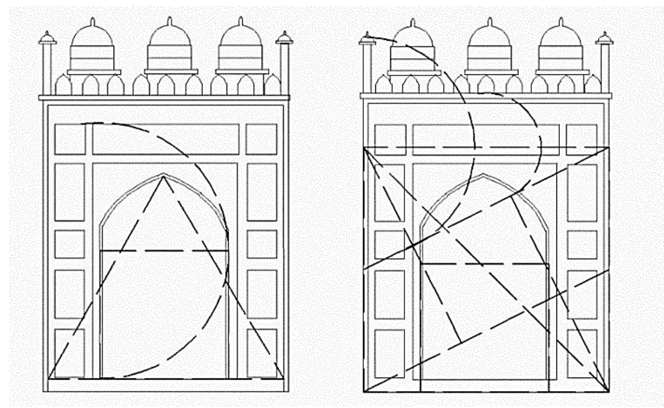
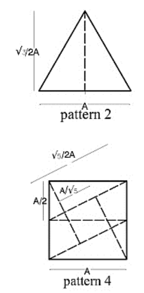
	plan	Geometrical patterns	facade	Geometrical patterns
Fatehpur sikri mosque South ivan				
Fatehpur sikri mosque east ivan				

Table D-5: Geometrical analysis of Shah Mosque (Safavid case studies (Author-2013)

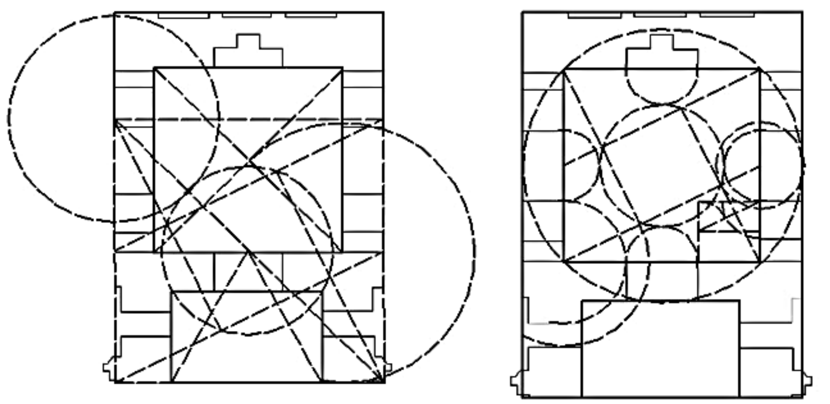
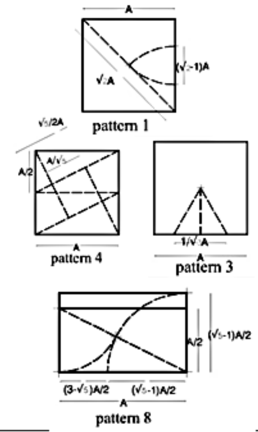
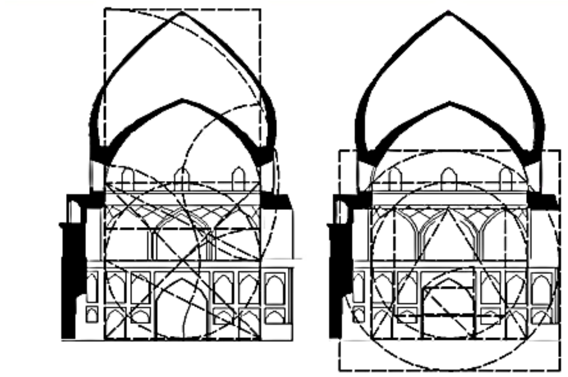
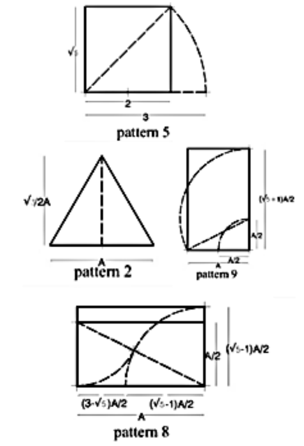
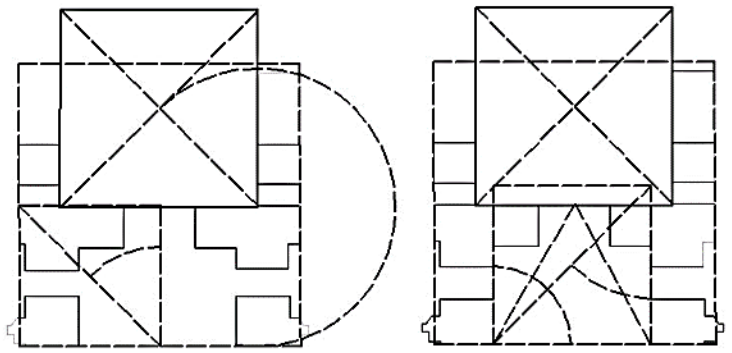
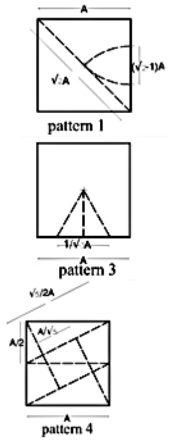
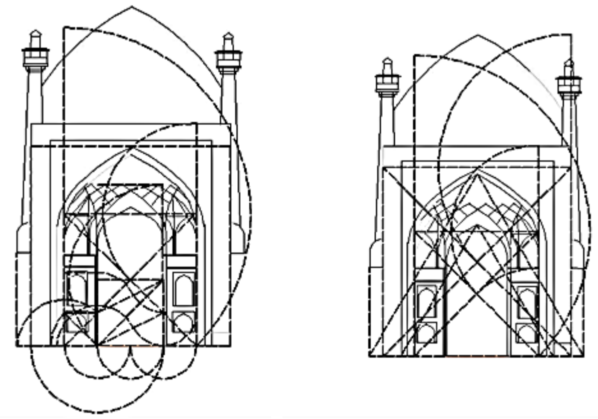
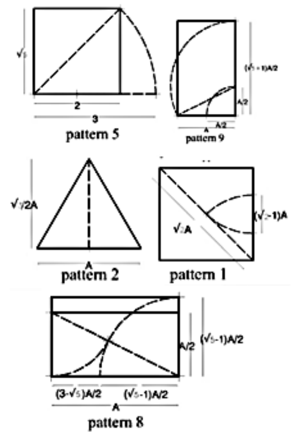
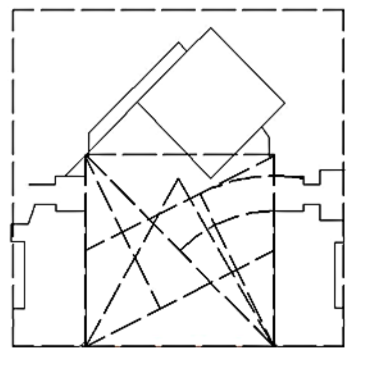
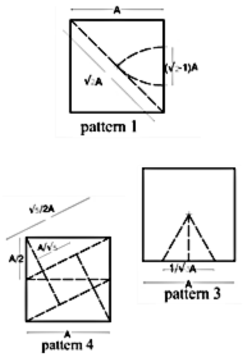
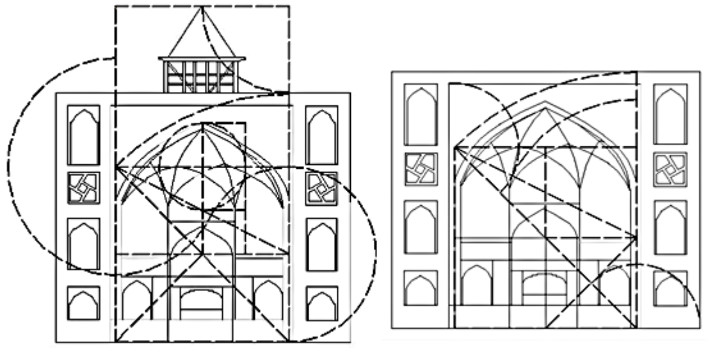
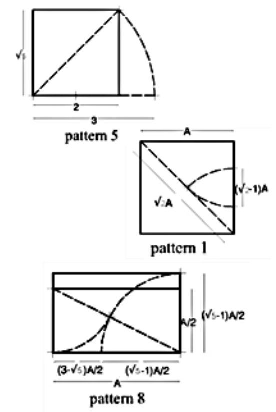
	plan	Geometrical patterns	facade	Geometrical patterns
Shah Mosque domed chamber				
Shah Mosque south I van				
Shah Mosque north &east & west I van				

Table D-6: Geometrical analysis of Taj Mahal Mosque (High Mughal case studies) (Author-2013)

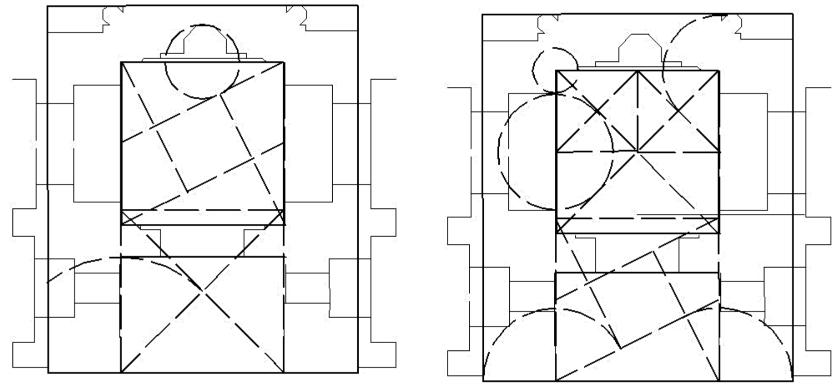
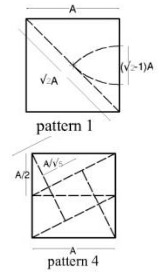
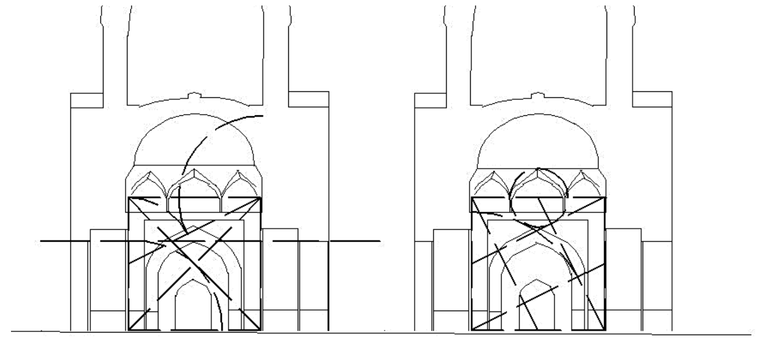
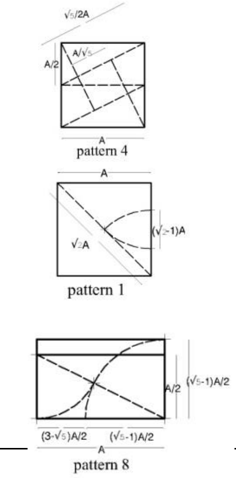
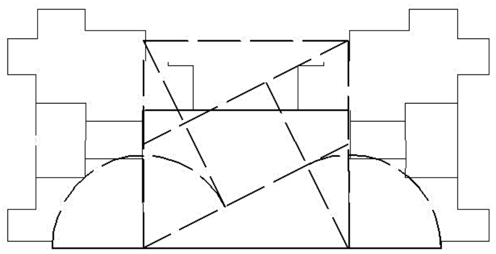
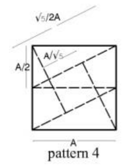
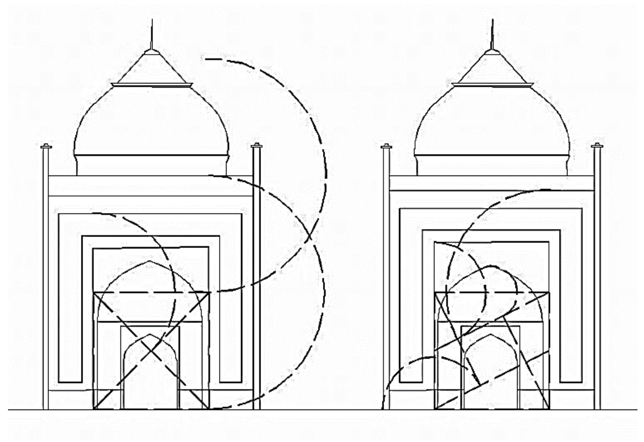
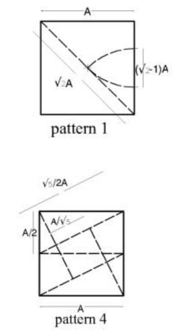
name of mosque	plan	Geometrical patterns	facade	Geometrical patterns
Taj mahal mosque domed chamber				
Taj mahal mosque West Ivan				

Table D-7: Geometrical analysis of Delhi Jami Mosque's *ivans* (High Mughal case studies) (Author-2013)

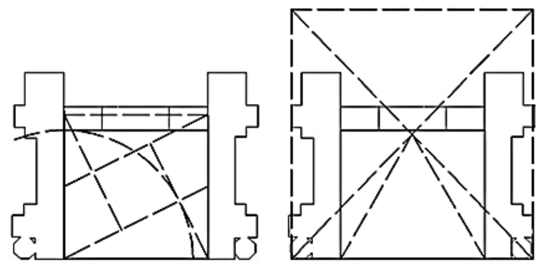
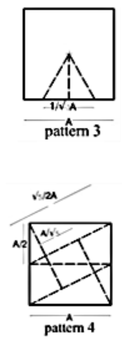
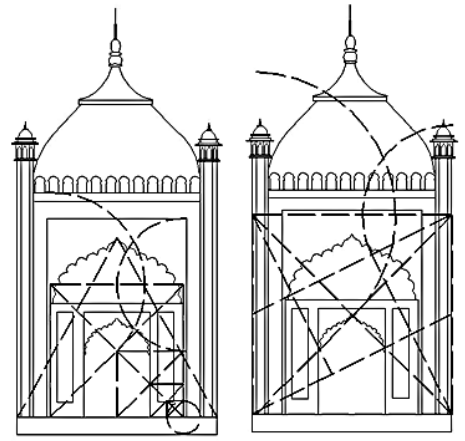
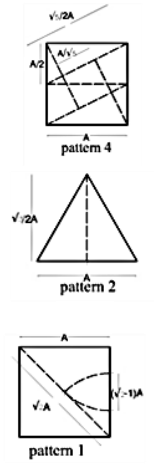
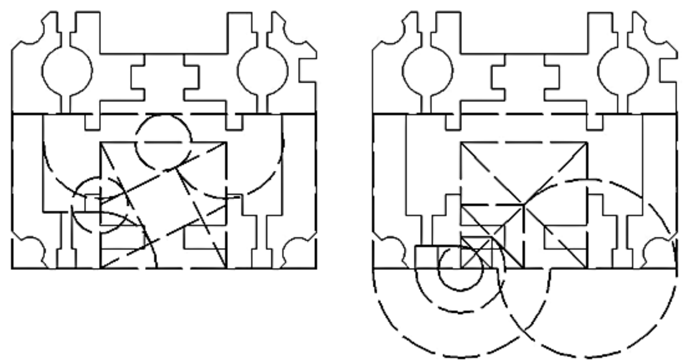
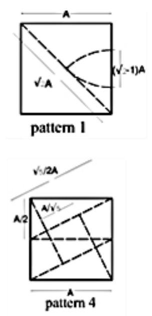
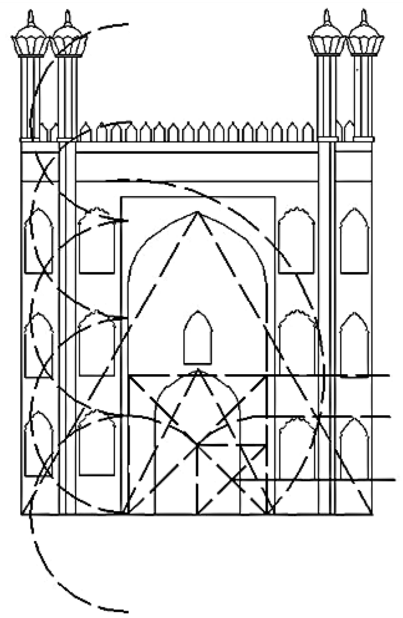
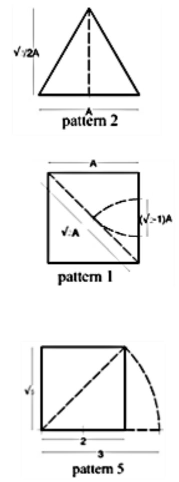
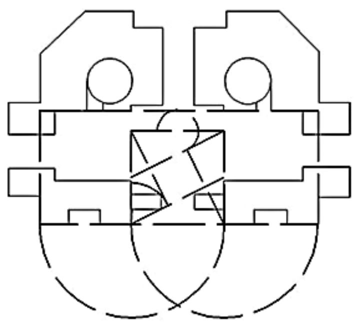
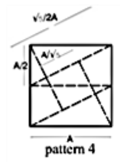
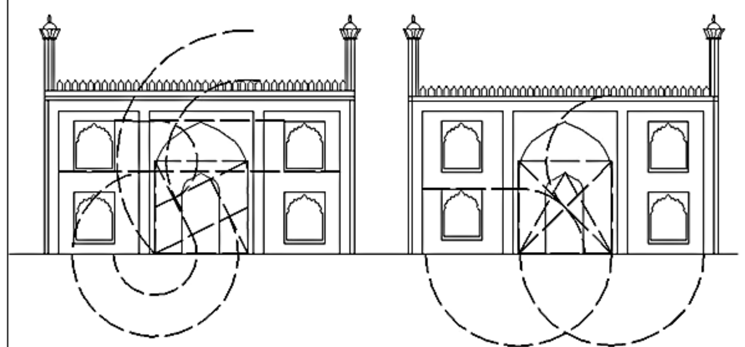
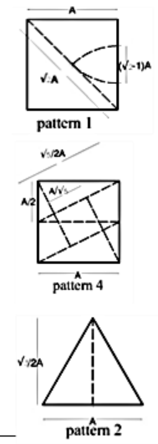
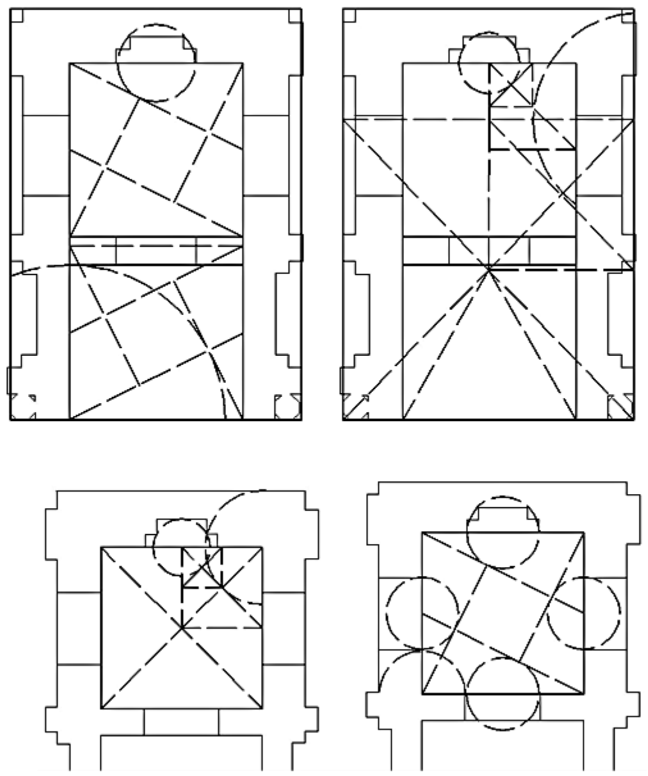
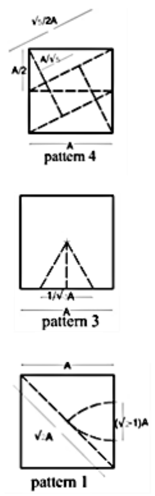
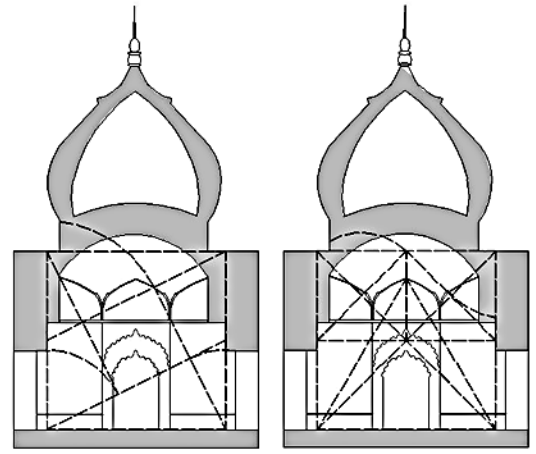
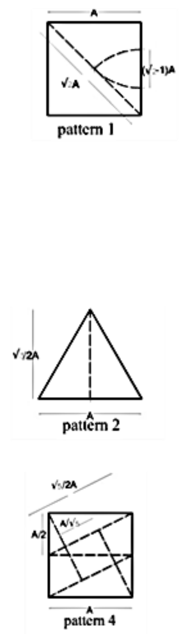
	plan	Geometrical patterns	facade	Geometrical patterns
Delhi Jame mosque West Ivan				
Delhi Jame mosque North and south Ivans				
Delhi Jame mosque east Ivan				

Table D-8: Geometrical analysis of Delhi Jami Mosque's domed chamber (High Mughal case studies) (Author-2013)

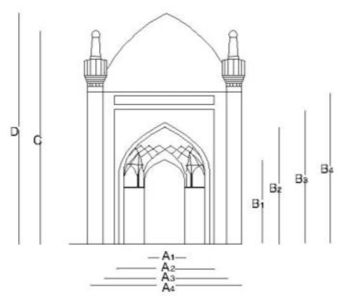
	plan	Geometrical patterns	facade	Geometrical patterns
Delhi Jame mosque domed chamber				

Appendix E: further proportions of Functional elements in case studies

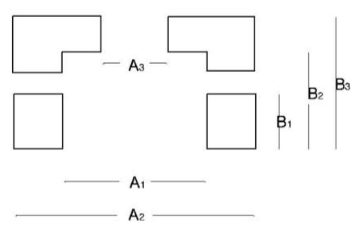
This section shows further geometrical analysis (for minor and major dimensions) about *ivans* of Timurid case studies.

Table E-1: Proportions of south *ivan*'s façade based on geometrical systems (Author-2013)

name of mosque	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4	C	D
Gohar Shad Mosque	-	a	$(2\sqrt{2}-1)a$	$\sqrt{5}a$	-	$\frac{(\sqrt{5}+3)a}{4}$	$\frac{(\sqrt{2}+2)a}{2}$	$(\sqrt{15}(\sqrt{2}-1)$	$\frac{3\sqrt{5}}{2}a$	$\frac{3\sqrt{5}}{2}a$
Mir Chaqmaq Mosque	a/2	a	$\frac{(\sqrt{5}+1)a}{2}$	$\frac{(\sqrt{5}+1)a}{2}$	$\frac{(\sqrt{2}+1)a}{2}$	$\sqrt{3}/2a$	$\frac{(\sqrt{2}+2)a}{2}$	2a	-	$(\sqrt{3}+2)a$
Mosque of Torbat Jam	a/2	a	$\frac{(\sqrt{5}+1)a}{2}$	$\frac{(\sqrt{5}+1)a}{2}$	$\frac{\sqrt{2}a}{2}$	$\sqrt{3}/2a$	$\frac{(\sqrt{2}+2)a}{2}$	$\frac{(\sqrt{2}+2)a}{2}$	-	-
Shah Mosque	a/2	a	3/2a	$\sqrt{5}a$	$\frac{\sqrt{3}(\sqrt{2}+1)a}{4}$	$\frac{\sqrt{3}\sqrt{5}}{2}a$	-	$\frac{(\sqrt{2}+2)a}{2}$	$(\sqrt{2}+1)a$	$\frac{\sqrt{5}(\sqrt{2}+2)a}{2}$



Key of Table XVI (vertical dimensions)



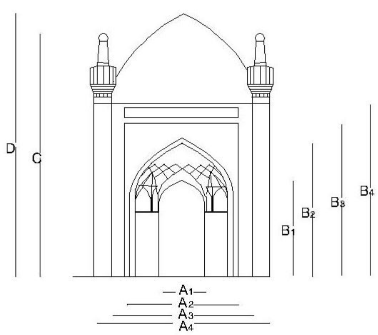
Key of Table XVII (horizontal dimensions)

Table E-2: Proportions of south *ivan*'s plan based on geometrical systems (Author-2013)

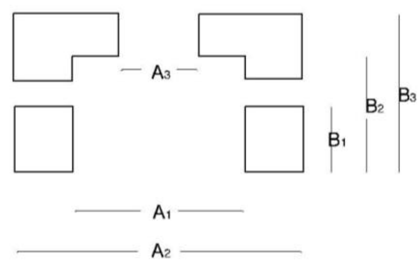
name of mosque	A_1	A_2	A_3	B_1	B_2	B_3
Gohar Shad Mosque	a	$\sqrt{5}a$	a	$\frac{a}{\sqrt{5}}$	$\frac{a}{\sqrt{5}}$	a
Mir Chaqmaq Mosque	a	$\sqrt{3}a$	$(\sqrt{3}(\sqrt{2}-1)a$	$\frac{(\sqrt{5}-1)}{\sqrt{5}}a$	a	$\frac{(\sqrt{3}+1)a}{2}$
Friday Mosque of Torbat Jam	a	$\sqrt{3}a$	a	$\frac{(\sqrt{3}-1)a}{4}$	$\frac{\sqrt{2}(\sqrt{3}-1)a}{2}$	$(\sqrt{3}-1)a$
Shah Mosque	a	$\sqrt{3}a$	$(\sqrt{2}-1)a$	$\frac{(2-\sqrt{2})a}{2}$	$\sqrt{3}\frac{\sqrt{2}a}{4}$	$\sqrt{3}/2a$

Table E-3: Proportions of north *ivan*'s façade based on geometrical systems (Author-2013)

name of mosque	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4	C	D
Gohar Shad Mosque	-	a	$\frac{(\sqrt{5}+1)a}{2}$	-	-	$\frac{(\sqrt{2}+2)a}{2}$	$\frac{(\sqrt{2}+2)a}{2}$	2a	-	-
Mir Chaqmaq Mosque	a/2	a	$\frac{(\sqrt{5}+1)a}{2}$		$\frac{(\sqrt{2}+1)a}{2}$	$\sqrt{3}/2a$	$\frac{(\sqrt{2}+2)a}{2}$	$\frac{(\sqrt{2}+2)a}{2}$	-	-
Friday Mosque of Torbat Jam	a/2	a	$\frac{(\sqrt{5}+1)a}{2}$	-	$\frac{\sqrt{2}a}{2}$	$\sqrt{3}/2a$	$\frac{(\sqrt{2}+2)a}{2}$	$\frac{(\sqrt{2}+2)a}{2}$	-	-
Shah Mosque	$\frac{\sqrt{2}}{4}a$	a	-	$\frac{(\sqrt{2}+2)a}{2}$	5/4a	-	-	$\sqrt{2}a$	-	-



Key of Table XVIII (vertical dimensions)



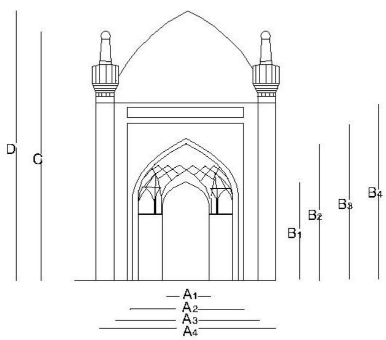
Key of Table XIX (horizontal dimensions)

Table E-4: Proportions of north *ivan*'s plan based on geometrical systems (Author-2013)

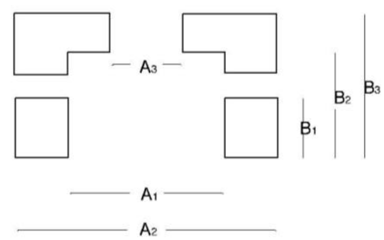
name of mosque	A_1	A_2	A_3	B_1	B_2	B_3
Gohar Shad Mosque	a	$\sqrt{3}a$	-	$\sqrt{3}\frac{\sqrt{2}a}{4}$	$\sqrt{3}\frac{\sqrt{2}a}{2}$	$\frac{(1+\sqrt{5})}{\sqrt{5}}a$
Mir Chaqmaq Mosque	a	$\sqrt{3}a$	$(\sqrt{3}(\sqrt{2}-1)a$	$\frac{a}{\sqrt{5}}$	$\frac{2a}{\sqrt{5}}$	$\sqrt{3}\frac{\sqrt{2}a}{2}$
Friday Mosque of Torbat Jam	a	$\sqrt{3}a$	a	$\frac{(\sqrt{3}-1)a}{4}$	$\frac{\sqrt{3}a}{\sqrt{5}}$	$\frac{(1+\sqrt{5})a}{2\sqrt{5}}$
Shah Mosque	a	$\sqrt{3}a$	-	$\frac{\sqrt{2}a}{2}$	$\frac{a}{2\sqrt{5}}$	a

Table E-5: Proportions of east and west ivan's façade based on geometrical systems (Author-2013)

name of mosque	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4
Gohar Shad Mosque	-	a	$\frac{(\sqrt{5}+1)a}{2}$	-	-	$\frac{(\sqrt{2}+2)a}{2}$	$\frac{(\sqrt{2}+2)a}{2}$	2a
Mir Chaqmaq Mosque	a/2	a	$\frac{(\sqrt{5}+1)a}{2}$		$\frac{(\sqrt{2}+1)a}{2}$	$\sqrt{3}/2a$	$\frac{(\sqrt{2}+2)a}{2}$	$\frac{(\sqrt{2}+2)a}{2}$
Shah Mosque	$\frac{\sqrt{2}}{4}a$	a	-	$\frac{(\sqrt{2}+2)a}{2}$	5/4a	-	-	$\sqrt{2}a$



Key of Table XX (vertical dimensions)



Key of Table XXI (horizontal dimensions)

Table E-6: Proportions of east and west *ivan*'s plan based on geometrical systems (Author-2013)

name of mosque	A_1	A_2	A_3	B_1	B_2	B_3
Gohar Shad Mosque	a	$\sqrt{3}a$	-	$\sqrt{3}\,\frac{\sqrt{2}a}{4}$	$\frac{a}{\sqrt{5}}$	$\frac{(1+\sqrt{5})}{\sqrt{5}}a$
Mir Chaqmaq Mosque	a	$\sqrt{3}a$	$\sqrt{3}\,\frac{\sqrt{2}a}{2}$	$\sqrt{3}(1-(\sqrt{2}/2))a$	a	$\frac{(\sqrt{3}+1)a}{2}$
Shah Mosque	a	$\sqrt{3}a$	$(\sqrt{2}-1)a$	$\frac{(\sqrt{3}-1)a}{2}$	$\frac{\sqrt{2}a}{4}$	a